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TECHNOLOGY DIVISION

THE MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK

Journal

INDEX

1921

VOL. 7

Edited by

ARTHUR W. TIDD,

Chairman PUBLICATION COMMITTEE

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New York

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ARTHUR W. TIDD
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Room 1347, Municipal Building, New York City

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THE MUNICIPAL ENGINEERS JOURNAL

Vol. 7 FIRST QUARTERLY ISSUE 1921

"The particular business and object of the Society shall be to promote and advance the various engineering sciences which are employed in the government of the City of New York, and to elevate the standard of efficiency of engineers employed in the various departments of The City."—*Constitution, Art. 1.*

PHILIP P. FARLEY
President, 1921

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ADDRESS OF PRESIDENT JOSIAH H. FITCH—ANNUAL MEETING, JANUARY 26, 1921

This is the seventeenth annual meeting of the Society of Municipal Engineers. In accordance with the time-hallowed custom and also in compliance with the requirements of the By-laws of the Society, the speaker is compelled to sing to-night his swan song as President, in the form of an annual report. He is as reluctant to perform this duty as you can possibly be to listen to him. The preparing end has been quite as painful to him as the receiving end will be to you. But you must submit with all the cheer and courage you can muster. That the speaker has not had time to compose a lengthy symphony is a subject, he thinks, for mutual congratulation.

The last annual report presented to you was by our greatly beloved President, Mr. Charles E. Gregory, who has since then, to our great regret and sorrow, passed away. His report was for the year 1918. Last year, owing to the ill health of your retiring President, Mr. Edward A. Byrne, no report was possible.

The speaker shall not try to cover the past two years, but will confine himself to the happenings of 1920, in so far as they affect this Society.

At the time of the last annual report, this country, as well as the rest of the world, was just emerging from the chaos created by the great war and entering upon a period of reconstruction and rebuilding and a return to the production of every-day necessities in sufficient quantities not only to supply the normal demand but to make good also the great shortage created by the cessation of such activities during the horrible years of war and war products.

All public improvements, except those directly necessary for the carrying on of the war by this country, were officially halted, and this as we all know reduced contract activities in this City to almost the vanishing point.

In 1919, the City caught its financial breath again and began to stir once more with work long over due. But the paralyzing effect of the years from 1914 to 1918 did not wear off fully until the beginning of 1920, when New York City once more got into her full stride of public improvement work.

The Board of Estimate and Apportionment in 1920 gave final authorization for 207 assessable public improvements of all kinds, such as sewers, paving, regulating and grading, etc., representing

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about $5,000,000 in cost, and in addition granted preliminary authorizations for 218 public improvements for the same class of work, representing nearly $9,000,000 in cost.

There have been built during 1920, 27.78 miles of sewers of all kinds and there are now in New York City 2,478.18 miles of sewers.

A total of 217,893 square yards of new paving, representing 15.19 miles of streets, has been laid, and New York City now has 39,776,010 square yards of paved streets covering 2,078.16 miles of roadways. This is exclusive of the Borough of Richmond for which there are no records. Repaving amounting to 878,971 square yards was done, extending over 50.13 miles of streets.

It may be interesting to know that in this great City there are now 3,638 miles of streets of all kinds, paved, unpaved, etc., that are open to public use, which, if put end to end would reach from here to San Francisco and down the coast to Los Angeles, or from here to London.

Statistics are tiresome things, but this also may be interesting:— New York City used during 1920 from all sources of supply an average amount of 690.3 million gallons of water per day, or the amazing total of 251,959,500,000 gallons of water during the year.

In order to meet the future demands of the City for more water, the Board of Water Supply has had in hand as its principal work during the past year, the development of the Schoharie watershed. The Schoharie watershed is equal in importance to the Esopus. Schoharie creek is in the higher part of the Catskills, north of the Esopus. The Esopus flows southerly towards the Hudson river at Kingston, while the Schoharie flows northerly to the Mohawk river near Amsterdam. The Schoharie is to be dammed at Gilboa and diverted through a tunnel under the Shandaken mountain range to Esopus creek near Allaben, 12 miles from the Ashokan reservoir. Thus the Catskill system will be extended 36 miles and 250 million gallons of water daily will be added to the supply. Work is under way on this Shandaken tunnel and it should be completed in about four years from the present time.

The Gilboa dam is also under construction and when completed will create the Schoharie reservoir with a 20-billion-gallon capacity. This work should also be completed in about four years from now. Substantial progress has been made during the year on the clearing of the land for the proposed reservoir and on the building of the new highways and bridges made necessary by the creation of this Schoharie reservoir.

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Permit the speaker to mention just a few more of the important things under way, or started or completed during the past year:

The Transit Construction Commission completed and put in operation 55.4 track-miles of the New York City rapid transit system, bringing into use a total track mileage of elevated and subway lines of 601.2 miles, out of a total of 618.7 miles of the entire Dual Rapid Transit system. There remain to be done 2.2 miles of Interborough lines and 15.3 miles of New York Municipal lines. One may now ride 26.63 miles on the Interborough system for 5 cents and 18.5 miles on the New York Municipal system. On the lines opened during the year there are 43 stations through which the average daily traffic is 350,000 passengers. Records show that there was an increase in traffic on the Rapid Transit railroads, elevated and subway, of about 211,000,000 during the year over 1919, the surface lines show an increase of approximately 65,000,000 passengers over the preceding year and in the Hudson and Manhattan tubes traffic increased 9,000,000 passengers, making a total increase on all lines in the City of about 285,000,000 passengers, bringing up the total of passengers during 1920 on all lines of rail transportation to 2,365,000,000.

Incidental to and closely connected with the matter of rail transportation was the interesting attempt made by the City under the supervision and control of the Department of Plant and Structures to operate bus lines to take the place of surface cars during a serious strike on such lines in Brooklyn and to compete with them after the strike was over, and also to operate where trolley-car service had been discontinued and on streets where bus service seemed to be urgently needed. The buses are privately owned but are operated under the direction of the Department of Plant and Structures. Their use proved to be a great boon to the public during the time trolley service was suspended and they even competed, and are still competing, successfully with active trolley-car lines.

An effort was made by the Board of Estimate and Apportionment to buy a large number of buses, but an injunction suit prevented the issuance of the bonds necessary to provide for their purchase. There is to be a determined effort made on the part of the present City administration to secure enabling legislation so that the City may be authorized to purchase and operate buses in quantity; and it will then be interesting to note which type of surface transportation will eventually survive,—track or bus. The mobile feature of

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bus service is one of its most important claims for serious consideration.

The most important work accomplished by the Department of Plant and Structures during 1920 was the actual placing under contract on October 26, 1920, of the work of the construction of a new bridge over Eastchester creek on Boston road at practically the northern limit of the City, which road is the main means of access to the City from the northeast. The building of a new bridge at this point has been a most urgent necessity for many years. The new bridge, taking the place of the present dilapidated and insufficient temporary structure, will be a two-leaf trunnion bridge with a roadway 53 feet wide and with sidewalks on each side 8.5 feet in width.

The picture the speaker has tried to roughly sketch is meant to show in a few lines what New York City has done in 1920 by and through its engineers. Not a single thing that is referred to here but what was conceived, initiated, developed and executed by engineers in the municipal service, and the hasty description given of these projects should, the speaker believes, make more evident than usual, what a great big City ours is, and yet how small, could one but picture it a century from now; and as years stretch out and this marvelous thing expands towards its unknown destiny it must be led in its growth to greater and more wonderful achievements by the engineer. The Municipal Engineer, however, has the advantage over the pioneer engineer who fought and conquered the frontier. We live here generally in a comfortable home and amid congenial surroundings, but the young railroad engineers of fifty years ago led the lives of pioneers and martyrs. They fought nature at every step and carried civilization with them. They marched through unknown parts of the world. They did better things than soldiers because soldiers destroyed and these young men created and made the way straight. They had no banners, nor brass bands. They fought mountains and rivers and were attacked on every side by fever and lack of food and exposure. They sat down around a camp fire at night and calculated whether they were to tunnel a mountain or turn the bed of a river or bridge it. And they knew all the time that whatever they decided to do out there in the wilderness meant thousands of dollars to stockholders somewhere up in God's country. They dragged their chains through miles and miles of jungle, over alkali beds and cactus, and reared bridges over roaring canons. And we to-day know nothing of them and

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care less. We ride over the roads they built in an observation car and look down thousands of feet into the depths they bridged and give them no thought. They were the bravest soldiers of that day, but their names are forgotten or were never heard.

The Municipal Engineer accomplishes fine things, but when one complains of the hard work he has to do, the speaker cannot but compare his lot, his surroundings and the conditions under which he works to those of the engineers who during the last century blazed the way and opened the roads that now tie this great land together.

The old and pleasant custom of an annual dinner was renewed in 1920 and the success attending the occasion was due undoubtedly to the fact that the principal purpose of the dinner was as a testimonial to our first President, Mr. Nelson P. Lewis, upon his retirement from active City service. This brings to mind an event that marked the year as one of the most important ever known to the Municipal Engineer and to all City and State employees. The speaker refers to the putting into effect of the new pension law that gives just recognition to long service and permits a disabled employee to retire on a fair and just pension.

In closing the speaker wishes to extend his profound thanks to his associates in the Board of Directors, to the other officers of the Society and to the Chairman and members of the various committees for the cordial, constant and efficient help that they have given him during his term as your President.

COME TO THE MEETINGS

You wouldn't lay aside, unopened, your *Engineering News* simply because you failed to see anything in the table of contents that appealed to you. Of course not! Similarly, you should come to the meetings on general principles, regardless of whether the subject appeals to you or not. You will surely pick up some information as well as enjoy the refreshments. Bring a friend!

INDEX FOR 1920

The Index to the JOURNAL for the year 1920 has been printed and will be furnished without charge to those who desire a copy.

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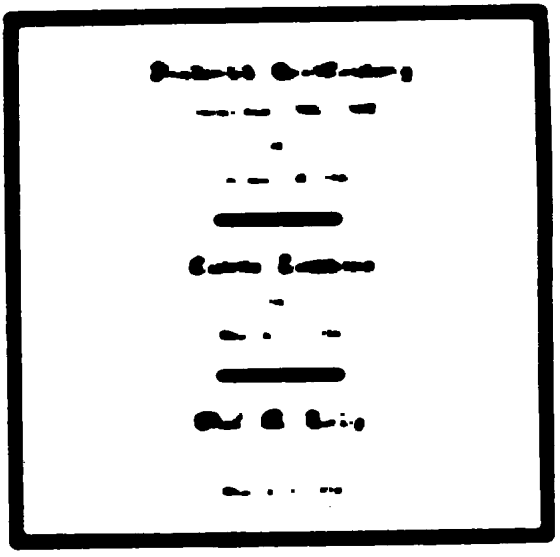

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ANNUAL MEETING OF THE SOCIETY, January 26, 1921.—President Josiah H. Fitch presided, and 330 members and guests were present. Ladies were invited to this meeting.

The minutes of the meeting of the Society held on December 22, 1920, were read and approved.

The Annual Report of the Board of Directors to the Society was read and accepted.

The President's Annual Address was presented by Mr. Fitch, in which the work of the year was briefly reviewed.

The speaker of the evening, Hudson Maxim, was then introduced. Mr. Maxim spoke on the subject "Lessons and Conclusions from the World War" in a very interesting manner.

The tellers appointed to canvass the ballots reported that 147 ballots had been cast, practically all in favor of the ticket as nominated, and the Chairman declared the following duly elected:

President	PHILIP P. FARLEY
First Vice-President	CORNELIUS V. V. POWERS
Second Vice-President	CHARLES U. POWELL
Secretary	VERNON S. MOON
Treasurer	HERMAN K. ENDEMANN
Director (one year)	RUDOLPH P. MILLER
Director (three years)	ARTHUR J. GRIFFIN
Director (three years)	AARON I. RAISMAN
Director (three years)	CLARENCE E. DOBBIN
Director (three years)	WARREN R. BORST
Director (three years)	ANDREW L. KOCH

By request of the Chairman, Past-Presidents Daniel L. Turner and William W. Brush escorted the newly elected President, Philip P. Farley, to the Chair.

Mr. Farley in accepting the office of President thanked the members for the honor conferred upon him and requested the co-operation of the members of the Society in the work of the coming year.

President Farley then presented to the retiring President, Josiah H. Fitch, the Past-President's Medal. Its acceptance was fittingly acknowledged.

The meeting adjourned and Colonel Merritt H. Smith took charge of the social features of the evening which consisted of refreshments and dancing.

BOARD OF DIRECTORS, February 23, 1921.—President Philip P. Farley presided. There were also present Messrs. Powell, Brush,

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Byrne, Fitch, Tidd, Miller, Bell, Attwater, Thomas, Ferris, Raisman, Dobbin, Borst, Koch and Moon.

The minutes of the regular meeting of the Board of Directors held on January 24, 1921, were read and approved.

The Finance Committee's report, submitting vouchers aggregating $468.37, was accepted and the bills ordered paid.

The Membership Committee reported favorably on the applications for admission as Member of N. W. STANLEY and ARTHUR C. FORBES, Assistant Engineers, Topographical Division, Bureau of Highways, Office of President of Borough of Brooklyn, and they were declared elected to membership, subject to confirmation by the Society.

MEETING OF THE SOCIETY, February 23, 1921.—President Philip P. Farley presided; 70 members and guests were present.

The minutes of the meeting of the Society held on January 26, 1921, were read and approved.

The Society confirmed the election by the Board of Directors of two members.

Dr. Royal S. Copeland, Commissioner of Health of the City of New York, then addressed the Society on the subject "The Pollution and Sanitation of Jamaica Bay," with particular reference to the closing of the bay as a source of oyster supply. Other phases of the question were taken up by Kenneth Allen, M. M. E. N. Y., Sanitary Engineer, Board of Estimate and Apportionment, and George T. Hammond, M. M. E. N. Y., Designing Engineer, Bureau of Sewers, Office of President of Borough of Brooklyn. An interesting discussion followed, after which the meeting adjourned and refreshments were served.

BOARD OF DIRECTORS, March 23, 1921.—Vice-President Cornelius V. V. Powers presided. There were also present Messrs. Endemann, Schaeffer, Turner, Tidd, Miller, Hunter, Riedel, Thomas, Ferris, Raisman, Dobbin, Borst, Koch and Moon.

The minutes of the regular meeting of the Board of Directors held on February 23, 1921, were read and approved.

The Finance Committee's report, submitting vouchers aggregating $580.24, was accepted and the bills ordered paid.

The Membership Committee recommended for reinstatement FREDERICK L. GREIFFENBERG, Assistant Engineer, Topographical

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Bureau, Office of President of Borough of Queens, stating that Mr. Greiffenberg had been a Charter Member and had resigned in 1904; the report was accepted and his reinstatement ordered. The Committee also reported favorably on the applications for admission as Member of the following:

EDWARD C. RANSON, Assistant Engineer, Bureau of Highways, Office of President of Borough of Brooklyn;

DAVID T. PITKETHLY, Assistant Engineer, Bureau of Sewers, Office of President of Borough of Brooklyn;

FRANK R. BARTLETT, Assistant Engineer, Bureau of Sewers, Office of President of Borough of Brooklyn;

WILLIAM P. HENNESSEY, Assistant Engineer, Bureau of Sewers, Office of President of Borough of Brooklyn;

ANDREW BIAGINI, Topographical Draftsman, Bureau of Sewers, Office of President of Borough of Brooklyn;

GUSTAVO J. STEINACHER, Chief Engineer, Department of Parks, Manhattan; and they were elected to membership, subject to confirmation by the Society.

Amos Schaeffer presented a communication from the Chamber of Technology submitting a constitution, statement of objects, obligations, and dues of membership which are by Societies. After a general discussion of the subject, the matter was referred to the committee that had previously had charge of this matter, consisting of Mr. Schaeffer and the Secretary, for further investigation and report.

MEETING OF THE SOCIETY, March 23, 1921.—Vice-President Cornelius V. V. Powers presided; 50 members and guests were present.

The minutes of the meeting of the Society held on February 23, 1921, were read and approved.

The Society confirmed the election by the Board of Directors of six members.

The paper of the evening entitled "Some Problems in City Planning for the Borough of Queens" was then read by the author, Charles U. Powell, M. M. E. N. Y., Engineer in Charge, Topographical Bureau, Office of President of Borough of Queens, and discussed.

The meeting then adjourned and refreshments were served.

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Total receipts	$4,271.21	
Total disbursements	4,197.68	
Excess of receipts over disbursements for current work during 1920		$73.53

During the year the Society's headquarters were moved from Room 715 to Room 601 in the Engineering Societies Building and a portion of the space rented to the American Society of Safety Engineers and the Metropolitan Section of the American Society of Mechanical Engineers.

The topics presented before the monthly meetings of the Society were varied in accordance with a pre-arranged program, for the purpose of meeting what seemed to be a popular demand for subjects of other than a technical character.

For the first time since the beginning of the War an Annual Dinner was held. This dinner was tendered as a testimonial to our first President, Nelson P. Lewis, on the occasion of his retirement from the City service; 330 members and guests attended.

Two unusually interesting inspection trips were arranged, one by autos to the Kensico Reservoir and the other to the Brooklyn Navy Yard.

In accordance with the action taken in the two preceding years, the effort to secure increased compensation for Municipal employees was continued and the Board of Estimate and Apportionment granted increases to practically all employees effective on August 20 last.

The work of the various Committees was continued during the year.

The reports of the Secretary, Treasurer and the standing Committees in which their respective work is detailed are recommended for your consideration.

Respectfully submitted,

BOARD OF DIRECTORS,

(Signed) VERNON S. MOON,

Secretary.

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Report of the Secretary

JANUARY 24, 1921.

THE BOARD OF DIRECTORS,

MUNICIPAL ENGINEERS:

Gentlemen: In accordance with Article VII of the By-Laws, the following report is submitted of the work of the Secretary for the year ending December 31, 1920:

STATEMENT OF RECEIPTS AND DISBURSEMENTS

(From January 1, 1920, to December 31, 1920,
With a Comparison for the Same Period Last Year)

RECEIPTS	1919	1920
Balance on hand January 1	$487.31	$911.72
Dues	3,303.25	3,173.75
Publication	629.89	454.50
Annual Banquet	.....	80.79
Badges	8.00	4.00
Certs. of Memb.	6.00	.....
Int. on Bank Bal.	9.86	23.37
Int. on City Bonds	150.00	130.00
Miscellaneous	.10	.....
Rent	75.00	370.00
Sale of Bond	934.05	.....
Rebate	.....	34.80
Totals	$5,603.46	$5,182.93

DISBURSEMENTS	1919	1920
Check for dues returned	$12.50	.....
Publication	1,513.22	$1,339.31
House	545.53	876.00
Refreshments	840.82	657.75
Inspections	39.08	32.90
Salaries	581.00	585.00
Printing	290.21	363.14
Postage	90.00	73.00
Treas. Bond	10.00	10.00
Certs. of Memb.	3.00	.....
Medals	68.36	68.05
Telephone	2.25	3.00
Miscellaneous	62.36	107.03
Entertainment	120.00	82.00
Keys returned	.....	.50
Note redeemed	500.00	.....
Interest on note	13.41	.....
	$4,691.74	$4,197.68
Bal. with Treas.	891.72	965.25
Bal. with Secy.	20.00	20.00
Totals	$5,603.46	$5,182.93

*CURRENT RECEIPTS AND DISBURSEMENTS:

	1919	1920
Current Receipts	$4,182.10	$4,236.41
Current Disbursements	4,178.33	4,197.68
Difference	+3.77	+38.73

*Balance on hand and extraordinary receipts and disbursements omitted.

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ASSETS AND LIABILITIES

(On December 31, 1920)

ASSETS		LIABILITIES	
Dues Receivable	$1,847.50	Bills Payable:	
Due from advertisements in JOURNAL	51.00	Rent of Meeting Room	$25.00
Books in Library	160.00	Assessment for storage space	12.00
Furniture	100.00	Balance	6,286.75
Office Equipment	150.00		
Proceedings in stock	240.00		
JOURNALS in stock	90.00		
One N. Y. City 4½% Corporate Stock. Market value on Dec. 31, 92	1,840.00		
One N. Y. City 4% Corporate Stock. Market value on Dec. 31, 82	820.00		
Cash with Treasurer	965.25		
Cash with Secretary	20.00		
Rental of Room 601	40.00		
	$6,323.75		$6,323.75

CHANGES IN MEMBERSHIP

(With a Comparison with Last Year)

	1919		1920	
Membership on January 1	514		475	
Elected and paid dues	18		26	
		532		501
Died	4		7	
Resigned	35		24	
Dropped for non-payment of dues	18		10	
		57		41
Membership on December 31		475		460

PUBLICATIONS

The receipts and disbursements during 1920 on account of the *Proceedings* and the JOURNAL are as follows:

RECEIPTS

Cash received from sale of *Proceedings*	$21.00
Cash received for advertisements in JOURNAL	398.50
Cash received from sale of JOURNALS	35.00
Total receipts	$454.50

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home in Providence, R. I., where he will resume private practice as consulting engineer on water supply, sewerage and valuation work.

CALVIN TOMKINS, Commissioner of the Department of Docks and Ferries of the City of New York during the years 1910 to 1913, inclusive, died on March 13, 1921. Mr. Tomkins was an ardent advocate of the development of the Port of New York and of the extension of its present harbor and docking facilities.

FREDERICK GREIFFENBERG died on February 25, 1921. He was retired from active duty a few years ago after having spent the greater part of his life in the City service, principally as topographical engineer in the Borough of The Bronx. He was a charter member of the Municipal Engineers of the City of New York and served as Director in 1903, 1904 and 1905.

RAYMOND J. REDDY, who was formerly with the Board of Water Supply and later with the Public Service Commission, has accepted a position with the Bronx Parkway Commission.

JOSEPH M. LONERGAN has recently contributed enlightening articles on the housing situation in the City of New York and also on the typhus situation. The articles appeared in recent issues of the Monthly Bulletin of the Department of Health.

OLAF M. KELLY, for many years assistant engineer in the Department of Plant and Structures, died March 13, 1921. Mr. Kelly had charge of the maintenance of the Williamsburg bridge for some time and more recently was in charge of that work for the Queensboro bridge.

WALTER E. SPEAR has resumed his position as Department Engineer with the Board of Water Supply, following a leave of absence during which he made investigations for water supply and drainage for the cities of Athens and Piraeus, Greece.

NELSON P. LEWIS has returned to New York after spending the winter on the Pacific coast. Mr. Lewis retired as Chief Engineer of the Board of Estimate and Apportionment in December, 1920, after a period of 35 years' service with the City.

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Mr. Holden had devoted much of his time to the perfection of a lineclinometer, an instrument which he had devised for use in measuring long triangulation base lines. This instrument serves as a measuring station and by means of a telescope the difference in elevation between stations is determined immediately. He had also devised and patented a tape stretcher for use in measuring triangulation base lines with long tapes. By the use of this stretcher, tension can be applied to any given amount and held without variation.

Mr. Holden was a member of the American Society of Civil Engineers, a member, and for many years Senior Warden, of St. Mary's Protestant Episcopal Church, Mott Haven, and a Charter Member of the Society of Municipal Engineers of the City of New York, in which latter organization he had served as a member of the Board of Directors for two full terms.

THE POLLUTION AND SANITATION OF JAMAICA BAY

ABSTRACTS OF ADDRESS BY DR. ROYAL S. COPELAND
Commissioner of Health of The City of New York

WITH DISCUSSION BY KENNETH ALLEN AND GEORGE T. HAMMOND

FEBRUARY 23, 1921, MEETING OF THE SOCIETY

It is not alone typhus that is menacing this country, but in large sections of Europe there are many cases of cholera. Cholera is a disease like typhoid fever, conveyed by food and drink and like typhoid fever the cholera patient may be perfectly immune himself but can spread the germs of that disease. You have heard of "Typhoid Mary"; she is at the Riverside Hospital of the Health Department. "Typhoid Mary" is just as well and healthy a woman as you ever saw, but she spreads the germs of typhoid and sixty cases of that disease have been traced to this woman and twenty deaths. Cholera is a disease like that and if the vigilance of the Department of Health were lax and a cholera carrier were to go to a watershed and contaminate the water-supply, influenza would seem like a summer picnic in comparison.

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bacilli. Every oyster sold in New York City coming from Jamaica bay is coli infected. It seems almost unbelievable that people would eat that sort of stuff.

We have reason in this City to be extremely proud of our milk supply. New York City has the purest milk supply of any city of the world. As you know, all the milk sold in this City, except a very limited amount of Grade A, is Pasteurized and the result is that we have cut down the infant death rate to 80 per thousand. Prior to 1901, out of every 1,000 infants, 241 died before they were a year old. The year before last it was only 80 per thousand, and last year it was 85. To a great extent, this is due to the almost entire absence of the diarrhœal diseases of infants, the reasons being that they no longer get milk containing the coli bacilli.

For grown-ups it is all right as far as the coli bacilli are concerned, for nothing can happen except an attack of dysentery. But the speaker pointed out that we had 57 cases of typhoid and nine carriers in this bay. Where coli bacilli go, typhoid bacilli might go and in these days cholera bacilli might go. The waters of Jamaica bay are hopelessly contaminated. The engineers of the City came to the speaker's office with charts showing the degree of contamination and the inspectors of the Health Department have maps showing where they had found gross fecal matters in the bay over the oyster beds; then with nine typhoid carriers living on the shores of the bay, it seemed to the speaker there was nothing in the world to do but say to these oystermen "You cannot sell any oysters in this City which are raised in the waters of Jamaica bay," so, the order of the Board of Health is that after March 31, 1921, no oysters will be permitted to be sold from Jamaica bay.

DISCUSSION

KENNETH ALLEN,* M.M.E.N.Y.—The importance of Jamaica bay is evident, the speaker thinks, to anyone who takes a glance at the map. The area is so great and the bay is so near large centers of population such as the Brownsville section of Brooklyn, Canarsie being a mile and a half nearer the New York City hall than Coney Island, that its accessibility is probably not realized. It is also accessible by water if the channel for shipping by way of the inlet is properly maintained, although at present its waters are shallow. Compared with the Paris of to-day, its tributary area is twice as great and by 1960 it has been estimated that it will contain three-

* Sanitary Engineer, Board of Estimate and Apportionment, New York City.

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fourths as great a population and produce 60 per cent. more sewage.

The pollution of the bay is mainly due to sewage which enters at certain points in the following amounts:

From Caisson No. 4 disposal plant on Shellbank creek	1.5 mgd*
From Paerdegat creek	8.0 mgd
From 26th Ward disposal plant on Second creek	25.0 mgd
From Jamaica disposal plant on Bergen creek	3.0 mgd
From Far Rockaway disposal plant on Nigger Bar channel	1.5 mgd
From miscellaneous small outlets, chiefly in the Rockaways	11.0 mgd
Total	50.0 mgd

The extent of the pollution was investigated by the Metropolitan Sewerage Commission in various ways. The underlying mud was examined microscopically for tissue and fibrous matter of sewage origin and also for bacteria, an excess above 10,000 per gram being considered positive evidence of pollution. Water samples containing over one million bacteria per c.c., or if B. coli were found in 0.01 c.c., was considered polluted. The waters were also examined as to the dissolved oxygen. All of these tests indicated gross pollution along the shores from Canarsie to Bergen creek on the north and from Arverne to Far Rockaway on the south.

More recent tests for dissolved oxygen made in 1916 by the United States Public Health Service showed minimum saturations as follows:

Canarsie	0 per cent.
Canarsie breakwater	35 per cent.
Far Rockaway	34 to 20 per cent.
Bergen beach	19 per cent.
Head of Big channel	47 per cent.
Arverne	30 per cent.
East of Barren island	43 per cent.
Fresh creek	33 per cent.

As a matter of comparison it may be said that the warm-weather average for the past year, as determined by the Board of Estimate and Apportionment, has been:

At the Narrows	52 per cent.
Lower East River	27 per cent.
Harlem river	23 per cent.
Hudson river below Spuyten Duyvil	44 per cent.

* Mgd = million gallons daily.

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Where the percentage of saturation falls below 30, the water may be said to be decidedly polluted.

In the interior of the bay there is little visible evidence of pollution although bacterial contamination is general, so that in 1914 Dr. Payne B. Parsons in a report to the United States Department of Agriculture stated that "Oysters taken from Jamaica bay during the summer season were found almost invariably to have scores above 50", this being the limit of contamination permitted by the Federal government. In this connection it may be said that although we hear more regarding the oysters of Jamaica bay, the clam industry is more extensive, the receipts from the sale of hard clams alone being about twice that from oysters in 1916, besides which there is a large consumption of "steamer" clams.

The capacity of the bay to receive sewage without creating a nuisance depends primarily on the dilution with fresh sea-water brought in through the inlet at each tide.

The tidal range is 4.3 feet, the average depth below low water 4.7 feet, the tidal prism 2,309 million cubic feet and the volume of the bay at mean low water 2,258 million cubic feet.

Now, the dilution depends solely upon the volume of sewage as compared with the tidal prism; therefore any encroachment on the latter by filling into new bulkheads, although improving sanitary conditions otherwise, reduces the dilution available. So, too, dredging or enlarging the capacity of the bay, so long as it is below the low-water level, has absolutely no effect upon the dilution factor.

The following figures serve as a basis for computing the probable dilution that will prevail in about 40 years if we ignore the effect of treating the sewage:

	1915	1960
Population tributary to bay	436,000	2,500,000
Sewage in mgd	50	296
Resulting dilution, assuming that one-sixth of the sewage passing out on the ebb returns on the next flood current	.....	1:194

This would be ample to prevent a nuisance if there were a uniform mixture throughout the bay, but this would be far from true if the waters continued to receive sewage collected to a few large outlets.

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Considering all the above facts, the speaker expressed the opinion in 1917 that "To prevent the formation of odors that would result from the putrefactive conditions following a material depletion of the dissolved oxygen, sewage discharged into the bay more than two or three miles above Rockaway inlet should, besides the removal of suspended matter, be subjected to some oxidizing treatment, such as filtration or direct aeration, that will render the effluent reasonably stable". In line with these conclusions a plan was outlined for discharging all the sewage collected from the north of the bay, off Barren island, after settling in tanks, and that from the Rockaways off Beach 149th street, after fine screening, with the proviso that if, as is not improbable, this concentration of sewage near the inlet should be found objectionable, that from the north side east of the Jamaica disposal plant should be diverted and treated by some oxidizing process before being discharged into the bay. An estimate of the cost of these works, on a pre-war basis, is as follows:

	Construction	Operation Per Annum
North side	$14,295,000.00	$494,000.00
South side	1,512,000.00	71,900.00
Total	$15,807,000.00	$565,900.00

The speaker is glad to be able to state that already the project, so far as it relates to the south side of Far Rockaway and the Rockaway peninsula, has been presented by the President of the Borough of Queens and approved by the Board of Estimate and Apportionment and that construction is likely to be taken up during the coming season. The completed project, if developed along these lines, will probably not be required for thirty or forty years. It will not make the bay safe for oyster culture but will suffice to prevent conditions otherwise unsanitary or objectionable.

George T. Hammond,* M. M. E. N. Y., then gave a very interesting description, accompanied by a large number of slides, of the experimental sewage-treatment station at the 26th Ward disposal plant, Brooklyn, and the work that he had been doing there in studying the various means for reducing the pollution of Jamaica bay.

* Designing Engineer, Bureau of Sewers, Office of President of Borough of Brooklyn.

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THE MUNICIPAL ENGINEERS JOURNAL

Vol. 7 SECOND QUARTERLY ISSUE 1921

"The particular business and object of the Society shall be to promote and advance the various engineering sciences which are employed in the government of the City of New York, and to elevate the standard of efficiency of engineers employed in the various departments of The City."—*Constitution, Art. 1.*

MEETINGS

Abstracts from Past Meetings

BOARD OF DIRECTORS, April 27, 1921.—President Philip P. Farley presided. There were also present Messrs. Powers, Endemann, Schaeffer, Turner, Tidd, Bell, Attwater, Thomas, Wood, Griffin, Raisman, Dobbin, Borst and Moon.

The minutes of the meeting of the Board of Directors held March 23, 1921, were read and approved.

The Finance Committee's report, submitting vouchers aggregating $270.55, was accepted and the bills ordered paid.

The Membership Committee reported favorably on the following applications for membership:

AS MEMBER

JOHN J. BRENNAN, Topographical Draftsman, Bureau of Sewers, Borough President's Office, Brooklyn;

HARRY W. LEVY, Assistant Engineer, Bureau of Design, Borough President's Office, Manhattan;

FRED S. TEBBUTT, Assistant Engineer, Department of Water Supply, Gas and Electricity;

AS ASSOCIATE MEMBER

CHARLES O. SNYDER, Axeman, Topographical Bureau, Borough President's Office, Queens;

and they were elected to membership subject to confirmation by the Society.

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The following were dropped for non-payment of dues: J. Brimberg, John P. Carver, William B. Caterson, Henry J. Clarkin, Guy W. Culgin, William J. Cunningham, Henry Heins, Jr., Arthur Hirschorn, Thomas Jennings, Milton Kempner, Michael Kraus, Francis L. Molanphy, Walter T. McIntosh, Alberto Schreiner, John Tackman, Benjamin H. Utal, Albert N. White, Willis M. Wilbur and Isidor Zwenig.

MEETING OF THE SOCIETY, April 27, 1921.—President Philip P. Farley presided; 80 members and guests were present at this meeting, to which ladies were also invited.

The minutes of the meeting of the Society held on March 23, 1921, were read and approved.

The Society confirmed the election by the Board of Directors of three members and one associate member.

The address of the evening was given by Arnold W. Brunner, President of the Fine Arts Federation of New York, on the subject of "The Practical Application of Artistic Principles to Municipal Work". Hon. Henry H. Curran, President of the Borough of Manhattan, and Nelson P. Lewis, M. M. E. N. Y., also spoke on this subject. A rising vote of thanks was tendered Messrs. Brunner, Curran and Lewis.

The meeting then adjourned and refreshments were served.

BOARD OF DIRECTORS, May 25, 1921.—President Philip P. Farley presided. There were also present Messrs. Powers, Endemann, Schaeffer, Turner, Brush, Tidd, Hunter, Riedel, Ferris, Wood, Raisman, Borst, Koch and Moon.

The minutes of the meeting of the Board of Directors held April 27, 1921, were read and approved.

The Finance Committee's report, submitting vouchers aggregating $259.82, was accepted and the bills ordered paid.

The following were dropped for non-payment of dues: F. X. A. Purcell and Henry T. Sutherland.

MEETING OF THE SOCIETY, May 25, 1921.—President Philip P. Farley presided; 55 members and guests were present.

The minutes of the meeting of the Society held on April 27, 1921, were read and approved.

A. B. Proal of the Robbins Conveying Belt Company addressed the meeting on the subject of "The Mechanical Handling and

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The decision has been made in the High Bridge matter by a resolution of the Board of Estimate and Apportionment, under the terms of which two or more of the channel spans are to be removed and replaced by a single arch. The work will be done under the jurisdiction of the Department of Water Supply, Gas and Electricity.

MEMOIR

FREDERICK GREIFFENBERG*

DIED FEBRUARY 24, 1921

FREDERICK GREIFFENBERG was born December 9, 1843, at Eppingen, Grand Duchy of Baden, Germany, and received his education at the Lyceum in Rastatt and the Polytechnic University at Karlsruhe in Baden. He was in the employ of the Baden Government on railroad construction from 1866 to 1868. He came to New York during April, 1868, and became a citizen of the United States of America in October, 1874. His first position was with John A. Roebling, the famous engineer of the first Niagara suspension bridge, working on plans for suspension bridges and superintending the erection of same.

The City of New York in 1871 intended to build a suspension bridge across the Harlem river at the site of the present Washington bridge and at the recommendation of Col. W. A. Roebling, Chief Engineer of the Brooklyn bridge, Mr. Greiffenberg was appointed by the Department of Public Works to make the plans and estimates; he also prepared the design for a tunnel under the Harlem river at Seventh avenue and other construction work relating to the parks and the present Borough of The Bronx.

From 1874 to 1891 Mr. Greiffenberg was engaged on various works under the jurisdiction of the Department of Public Parks, especially the laying out of the street systems north of Dyckman street and the annexed 23rd and 24th wards, acting as First Assistant Engineer to the Topographical Engineer.

In January, 1891, Mr. Greiffenberg became Principal Assistant Topographical Engineer under the Commissioner of Street Improvements of the 23rd and 24th wards. Greater New York having been created in January, 1898, the Board of Public Improvements established a Topographical Bureau for the whole City, in which Mr. Greiffenberg held the position of Principal Assistant Topo-

* Memoir prepared by FREDERICK GREIFFENBERG, JR.

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THE DEVELOPMENT OF THE SANITARY SAFEGUARDS OF THE NEW YORK CITY WATER SUPPLY AND ITS RELATION TO TYPHOID FEVER AND OTHER DISEASES*

By Frank E. Hale,† Ph. D., M. M. E. N. Y.

The data included in this report cover the improvement of the water supply of Greater New York, particularly during the last ten years. In some respects it has been necessary to go back twenty years in order to give the proper setting to the data. It has also been necessary to submit the data in great detail, since the water supply of New York City is of such complication that the details must be known in studying the health statistics of any one section.

1. *What changes in the mineral content of the water of Greater New York have occurred during the past ten years with particular reference to those mineral changes tending to be productive of digestive disorder?*

It is not probable that any permanent digestive disorders have been caused by the mineral content of the water supply of New York City. It is true, however, that a change from a hard supply to a soft supply, or *vice versa,* may induce temporary disorder such as constipation or diarrhœa. In addition to this, large amounts of nitrate probably produce a diuretic effect and in certain cases of idiosyncrasy may produce itching of the skin. Continuous small amounts of lead, even as low as 0.5 part per million, may produce serious lead poisoning.

Taking up these points in reverse order:

It has been the policy of the Water Department for many years to require lead service from the building to the mains. Analyses and experiments connected with lead in the supply have indicated that this is of no serious moment.‡

Several of the water supplies have in the past contained considerable nitrate, as high as 20.0 parts per million, expressed as nitrogen. It probably takes about 40.0 parts per million to cause a diuretic effect, so that the City's supplies have probably not had any effect.

* Prepared for the International Health Board, at the direction of Merritt H. Smith, M. M. E. N. Y., Chief Engineer, Department of Water Supply, Gas and Electricity, New York City.

† Chief Chemist, Department of Water Supply, Gas and Electricity, and Director of the Mt. Prospect Laboratory, New York City.

‡ These experiments were, however, made several years ago, previous to the introduction of the very soft Catskill supply.

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With regard to hardness, many sections of the City have been supplied from well sources and there have been frequent changes from one supply to another. In addition there are very few closed services, so that daily mixing of different supplies has occurred. Also frequent variations in the mineral content of any one supply have occurred. In the accompanying table, No. 1. (Analyses Corresponding to Changes in Water Supply), are shown in as complete form as possible the changes which have occurred, including the date of change, borough, section supplied, population (estimated from per capita consumption and million gallons pumped daily), the supplies involved and the changes in hardness, alkalinity, nitrate, chloride, solids, microscopic organisms, bacteria and B. coli.

The sections showing the greatest changes in hardness are Long Island City, Coney Island (including portions of the 30th, 31st and 32nd wards of Brooklyn) and the North Shore of Staten Island (Ward 1). Intensive detailed study of these sections should reveal any differences in causes of death if such have resulted from changes in water supply. We would be particularly pleased to learn the results of such a study since the effect of hardness in water supply is a mooted question, particularly with reference to rheumatism, gouty conditions, calcareous deposits, etc.

Not only have there been changes due to change in water supply but in some instances radical changes in the same supply, for example:

GRAVESEND WELLS

Year	Hardness	Alkalinity	Nitrate	Chloride	Solids	Bacteria	B. coli—Per Cent. 0.1–1.0–10cc
1910....	133	63	5.05	42.0	240	330	2–11–21
1911....	170	61	3.65	77.9	343	13	0– 0– 6
1912....	201	63	3.30	99.9	366	1	0– 2–15
1913....	201	64	3.30	97.4	389	1	0– 0–17
1914....	343	65	2.86	213.3	662	2	0– 2– 8
1915....	285	69	2.90	171.3	665	9	0– 0–23
1916....	320	68	2.66	266.8	724	3	0– 0– 0

In the above averages note the increases in mineral content occurring in 1911 and in 1914, each increase lasting about three years.

The following table shows the high mineral content of the West New Brighton wells, Staten Island:

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WEST NEW BRIGHTON WELLS

Year	Hardness	Alkalinity	Nitrate	Chloride	Solids	Bacteria	B. coli—Per Cent. 0.1–1.0–10cc
1910....	496	97	2.39	580.3	1,436	128	0– 9– 9
1911....	413	89	2.01	453.8	1,215	113	0– 0–17
1912....	428	89	1.27	481.7	1,298	45	0– 0–33
1913....	429	90	1.18	518.0	1,347	65	8–33–42
1914....	341	88	1.37	419.0	1,090	65	0– 8– 8
1915....	325	87	1.27	406.0	1,028	31	0– 0– 0
1916....	234	86	1.20	247.0	683	20	0– 0– 0

In both the above cases the change from a very hard supply to the very soft Catskill supply should have shown an effect upon the health if such is possible, and the above sections are more nearly closed sections than Long Island City.

2. What changes have there been in the organic content of the water supply which tend to be productive of digestive disorder?

The organic content of well supplies is practically *nil,* and the organic content of the surface supplies has also been very low as exhibited in low color, low loss on ignition of solids and usually low average microscopic organisms. A certain amount of swamp water enters the supplies and much surface wash from the soil, including fecal deposits from animals—although this is tremendously diluted. The chief organic content is probably due to growth of microscopic organisms which are not known to have any specific effect upon the health, although they frequently produce disagreeable taste and odor when present in amounts above 1,000 units, depending upon the species present. Such odors are chiefly aromatic, grassy, fishy and oily. They might at times affect the appetite. Every means available is taken to suppress or avoid these growths in order to improve the esthetic quality of the water supply. (Note section on this subject in paper by the writer entitled "Safeguarding Water Supply of New York City").*

The bacterial content of the water supply may also be considered organic but will be considered in connection with typhoid fever, etc.; every effort has been made to improve the water supply and avoid human contamination. (Note the contents of above-mentioned paper, particularly the sections on inspection, sewage disposal and chlorination.)

* Journal, Municipal Engineers of the City of New York, May–June, 1919.

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In the above-mentioned table (No. 1) of mineral changes are included the average figures for microscopic organisms, bacteria and B. coli.

3. *What changes have there been in the water supply which tend to increase or decrease the prevalence of typhoid or other communicable diseases?*

Every effort has been made from every standpoint to insure that the quality of the water supply shall be irreproachable. A general résumé of the methods adopted and care taken is given in the above-mentioned paper on the safeguarding of the supply. In order to have as complete data as possible the following has been compiled covering the last ten years:

HISTORY OF CHANGES IN THE WATER SUPPLY AND POLICIES AND METHODS ADOPTED TO IMPROVE THE SUPPLY.

1909—Started direct test for B. typhi in the water supply by the Laboratory division.

1909—August 10—Started Canarsie pumping station, supplying hard well water to Canarsie, the well water also mixing with Long Island water supplying the section near Hamilton Parkway in the 30th and 31st wards, Brooklyn.

1909—City acquired ownership of the plants of Staten Island Water Company, supplying 1st and 3rd wards, Richmond.
City acquired ownership of the plants of Crystal Water Company, supplying 2nd and 4th wards, Richmond.

1910—Increase in mineral constituents of West New Brighton pumping station water supplying North Shore, Richmond, Wards 1 and 3.
Increase in mineral constituents of Grant City pumping station well water supplying the South Shore, Richmond, Wards 2 and 4.

1910—February 16—About 4 mgd* of Forest Park well water (hard supply) mixed in Myrtle Avenue main, Brooklyn, with Long Island water,—capacity of main 20 mgd (complaints of hardness from manufacturers).

1910—February 18—New Utrecht pumping station, Brooklyn. abandoned. Supplied Coney Island and portion of 31st ward. Water high in chlorides and hard.

1910—April 13—Start of Titus 6th Street wells, between 3rd and 4th avenues, Brooklyn. Water pumped to mains of neighboring section, mixing with Long Island water. (Local complaints of hardness from industrial concerns.

* mgd = million gallons daily.

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1910—April 30—Discontinuance of purchase of water from the Bowery Bay Improvement Company (North Beach pumping station). Water of similar character, however, served to section, Steinway. Water hard.

1910—August 11—Linoleumville pumping station, Staten Island, abandoned. Supplied portion of 3rd ward.

1910—June—Hunters brook pollution (Croton lake) from toilets of construction camps on Catskill aqueduct resulted in start of chlorination by crude methods at the Screen chamber, Croton aqueduct; at various times during the year treatment was repeated but was not continuous; also January 7 to 13, February 4 to 7, and March 9 to 12, 1911.

1910 -June 24—Beginning of chlorination with bleach of Bronx watershed; continuous treatment, because of construction gangs at Kensico dam.

1910 -Lowest rainfall since 1826 (34.67 inches), Long Island watershed. Increased chlorides and mineral constituents of the Brooklyn supply.

1910 -Survey of Croton and Brooklyn watersheds by special committees representing the Water, Health and Law departments. —the Water Department represented by D. D. Jackson, Director of Laboratories, and T. DeL. Coffin, Assistant Engineer in charge of Sanitation, Croton watershed, the Health Department by Dr. Charles Bolduan and Dr. M. B. McMillan and the Law Department by I. J. Beaudrias for the Croton watershed; and for the Brooklyn watershed, the Water Department by D. D. Jackson, Director of Laboratories, and W. F. Laase, Assistant Engineer, the Health Department by Dr. M. B. McMillan, and the Law Department by Ed. S. Malone.

The above committees examined all nuisances and probable sources of contamination, classifying them under the following headings:

1. Where the nuisances can be abated without destroying the use to which the property is devoted;
2. Where the community is so large that the continuous pollution would be so great that it would be impracticable to abate the numerous nuisances individually, and general or local disposal of the sewage and waste water will be necessary;
3. Where to abate the nuisance would destroy the use of the property, so that the remedy would confiscate the land;
4. Concerted action was taken towards the removal of the most dangerous nuisances and effective work was accomplished, some nuisances which had existed for many years having been abated.

1911—February 7—Sedimentation tank and tile underdrain irrigation treatment of chlorinated Brewster sewage removed to new location below diverting basin.

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1911—July 12—Electrozone sewage disposal plant at Brewster, Croton watershed, burned down.

1911—July 12—Bleach plant started to sterilize Brewster sewage in place of destroyed Electrozone plant.

1911—February 28—Madison Avenue new wells (although high in iron) started operation to help reduce mineral content of West New Brighton pumping station water, Richmond.

1911—April—Started chlorination of Mt. Kisco river (Croton watershed) by bleach plant.

1911—June—Started systematic chlorination of Croton water continuously by bleach plant at Shaft 9, New aqueduct, Pocantico Hills.

1911—July 27—Bronx dike put into commission during construction of Kensico dam.

1911—August 14—Bayside filter plant put into operation filtering water of Oakland lake, Flushing supply, Queens.

1911—September 18—Whitestone new wells shut down on account of high iron content. Replaced by softer water of Flushing Pumping Station wells, Queens.

1911—October 3—Beginning of purchase of water from Urban Water Company (hard supply). Supplied portion of Long Island City, 2nd ward, Queens.

1911—Long Island City Pumping Stations Nos. 1 and 3 shut down for several years. Supplied Long Island City, Queens.

1911—December 6—Long Island City Station No. 2 abandoned on account of high chlorides and hardness. Supplied Steinway. Replaced by water of similar character, but containing less chloride, obtained from Citizens Pumping Station No. 2.

1911—Increased pumpage at Gravesend pumping station increased the chlorides and hardness in that well supply. Supplied to Coney Island and a portion of 31st ward, Brooklyn.

1911—Croton reservoirs depleted during first six months by low rainfall, 15 per cent. below normal for 43 years.

1911—Appropriation of $8,690,000 for Jerome Park filter plant, Croton water. Later rescinded. Bids obtained but plant never built.

1912—January 15—Shetucket wells, Long Island watershed, and

1912—January 17—Morris Park wells, Long Island, abandoned because of high chloride content. Influenced Brooklyn supply.

1912—January 17—Boulevard temporary pumping station started, replacing a portion of the Grant City pumping station water of higher chloride content, Richmond.

1912—March 13—New Lots new wells replaced New Lots old wells supplying a portion of the 26th ward, Brooklyn.

1912—March 21—Use of Baiseley filter plant (rapid type) begun

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... water ... Jamaica pumping ...

... started ... chlorination of ...

... same Grant City ... water in the inter- ...

... and at Smith pond, ...

... chlorinate Lake ... surface drainage ... Croton water- ...

... water to obtain ... microscopic organ- ... at New Croton dam and ... the New aqueduct ... dam. The effect of ... the water reaching ... the summer and ... organisms was ... many complaints ... The following table shows ...

... OCTOBER AND SEPTEMBER

Year	...	...	Reduction in Organisms Per Cent.
...	...	...	...
...	...	...	85
...	...	...	75

1912—In the ... intermittent shallow ... 100 parts per million ... from two to three weeks time to ... settle out. The Bronx and ...

1912—Reconstruction of Croton aqueduct started.

1912—Investigation ... water examined by committee ...

1913—February—New ... plant put into operation. Purification ... operation.

1913—May 8—Forest Park ... Brooklyn, discontinued.

1913—May 8—... plant started ... Croton water.

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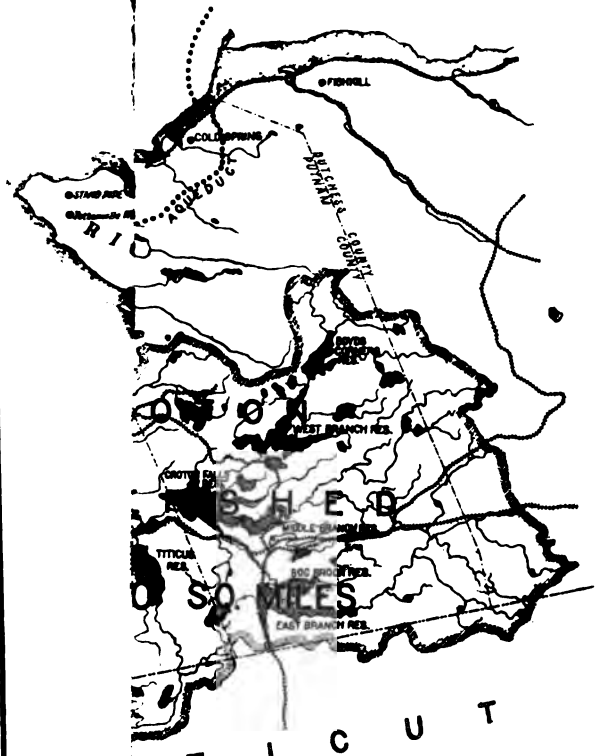

CITY OF NEW YORK

DEPT. OF WATER SUPPLY, GAS & ELECTRICITY -

BUREAU OF WATER SUPPLY

SOURCES OF

MUNICIPAL WATER SUPPLY

AUGUST 1915

Scale of Miles

1 0 1 2 3 4

CHIEF ENGINEER

ROBERT A. WELLCKE, PHOTO-LITH, 175 WILLIAM ST, N.Y.

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to remove iron from the shallow well water of Jamaco pumping station, Long Island watershed.

1912—July—Katonah chlorination plant started chlorination of Katonah brook, Croton watershed.

1912—September—The harder and the more saline Grant City pumping station water replaced Clove well water in the intermediate service, Richmond.

1912—October 19—Operation started of bleach plant at Smith pond, Long Island watershed.

1912—Chlorination plant built at Carmel to chlorinate Lake Gleneida during draft. This lake receives surface drainage from Carmel and enters West Branch reservoir, Croton watershed.

1912—Policy of deep draft at Croton lake started in order to obtain water cooler, clearer and more free from microscopic organisms. Draft at about 75-foot depth at New Croton dam and water run back through the Old aqueduct to the New aqueduct gate-chamber near site of submerged old dam. The effect of this policy is shown by the fact that in 1912 the water reaching the City was 5 to 10 degrees cooler during the summer and trouble from heavy growths of microscopic organisms was avoided. For example, during 1910 and 1911 many complaints were caused by Aphanizomenon. The following table shows the beneficial effect clearly:

THIRD QUARTER—JULY, AUGUST AND SEPTEMBER

Year	Temperature Degrees	Microscopic Organisms	Reduction in Organisms Per Cent.
1911.....	72	2,836	..
1912.....	67	1,072	65
1913.....	65	677	75

1912—In the spring of the year owing to considerable shallow flowage, heavy rains caused a high turbidity (100 parts per million) in the Croton water which lasted from two to three weeks due to the inability of the fine silt to settle out. The Bronx and Brooklyn supplies were also affected.

1912—Reforestation of Croton watershed started.

1912—Investigation of proposed filtration of Croton water examined by committee of experts and reported upon.

1913—February 1—Mt. Kisco sewage disposal plant put into operation. Purifies sewage of village of 3,000 population.

1913—May 8—Forest Park wells, Brooklyn, discontinued.

1913—May 9—Dunwoodie plant started, chlorinating Croton water,

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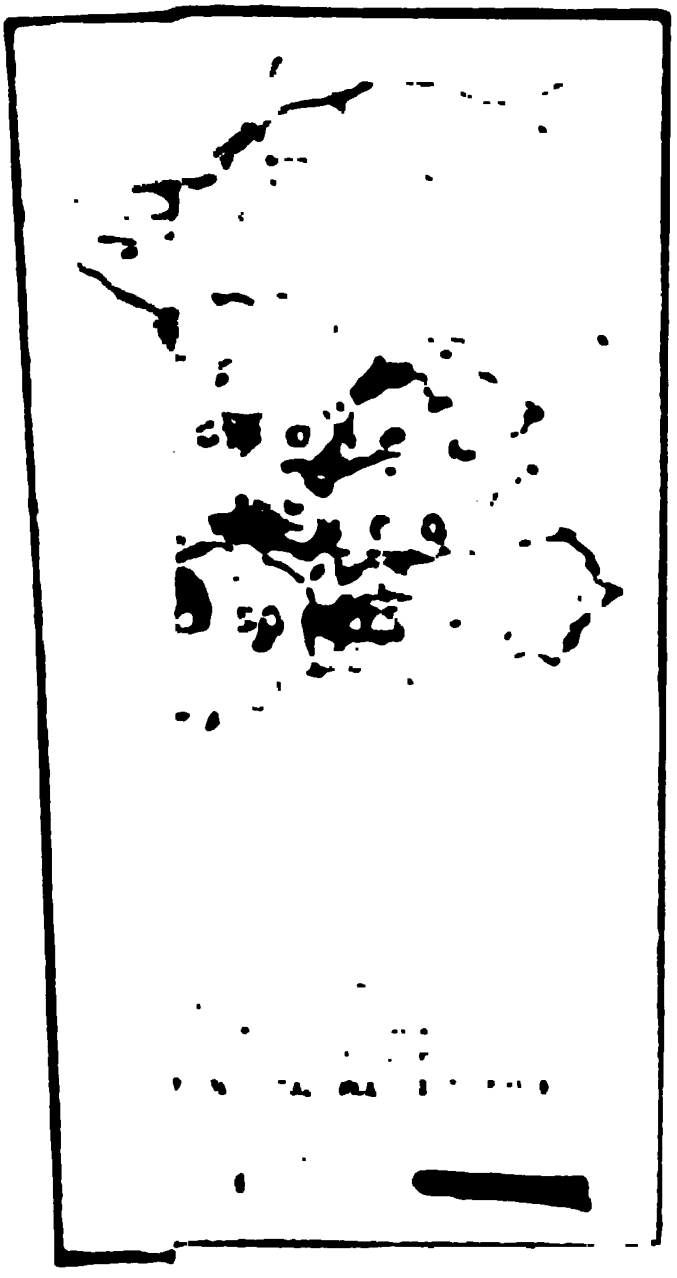

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Old and New aqueducts, with bleach,—in place of Pocantico plant.

1913—May 16—Three mgd of Long Island water sent to Queens to replace the harder well supplies of Long Island City Stations Nos. 1 and 3 (shut down May 21) and a part of well water of Urban Water Company.

1913—June 15—Long Island water to Queens increased to 6-7 mgd replacing 3-4 mgd of Citizens Water Company well water.

1913—August 24—Purchase of water from Urban Water Company discontinued. Supplied portion of Long Island City.

1913—September 29—Beginning of application of bleach to effluent of Mt. Kisco sewage disposal plant, Croton watershed.

1913—October 29-November 11—First operation of Gleneida chlorination plant, built the previous year.

1913—November 29—Liquid chlorine replaced bleach at Bronx Pipe-Line plant, Valhalla.

1913—December 17—Electro-bleach chlorine machine installed at Smith Pond pumping station to chlorinate conduit water and replace bleach plant. Amount of water chlorinated increased from an average of 8 mgd to 16 mgd. Hempstead pond, Storage reservoir, Pines pond and Smith pond chlorinated, Long Island watershed.

1913—June to August—Test of Leavitt-Jackson liquid chlorine machine at Ridgewood reservoir, Brooklyn.

1913—Excess of flow on Croton watershed due to heavy rains.

1913—Attempt to improve supply to City by shifting draft from surface to bottom or *vice versa* and from Old dam to New dam of Croton lake according to analyses for B. coli. Not found particularly practicable owing to delay in obtaining results of analyses, rapidly changing results and amount of labor involved.

1913—Patrol districts and several daily routes to each district arranged for inspectors of Croton watershed.

1913—Commencement of intensive effort at mapping and indexing description of possible sources of pollution on Croton watershed (approximately 5,000 in number); 1,213 premises finished that year.

1913—Sweeping bridges on the Croton watershed begun in order to reduce contamination from horses. Later discontinued.

1913—Appropriation of money for Jerome Park filtration system rescinded on May 22 by Board of Estimate and Apportionment and on June 3 by Board of Aldermen.

1913—In this connection consideration was given to methods of protection without filtration such as: Prevention of pollution from railroad trains, prevention of pollution from high bridges, aeration, additional control of microscopic growths by draining swamps—by-passing of reservoirs—reduction of shallow flow-

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age, reforestation of watershed, treatment of road wash, treatment of wash from cultivated lands and purchase of protecting strips of land.

It was estimated that the above would cost about $24,179,000 against the $7,500,000 for filtration.

Several of the above items have had considerable attention, for instance:

Toilets are locked on trains while crossing the watershed, sweeping of bridges to eliminate horse droppings was carried out for some time, microscopic organisms are largely controlled by varying draft at reservoirs from top to bottom or from one point to another, shutting off reservoirs or by-passing them when possible, treatment with copper sulphate, regulating draft on reservoirs to avoid shallow flowage, etc., reforestation of watersheds has been extensively carried on, road wash and wash from contaminating solids is avoided when possible, as by formation of ponds or small filters or absorption trenches or chlorination. (Illustrations may be found at Charter brook, Brewster, and Purdy's Station.)

1913—Reduction of iron in Long Island supply to Brooklyn (0.7 to 0.35 part per million) by shutting down high iron stations, Rosedale and St. Albans, and by operation of Baiseley's and Springfield mechanical filter plants for iron removal from the high iron well waters at these stations.

1914—July 21—Wallace & Tiernan machine replaced Electro-bleach machine at Smith Pond station, Long Island watershed.

1914—August 21—Queens County Water Company started operation of filter plant (rapid type) for iron removal from Rockaway Park well water.

1914—September 19—Liquid chlorine machine (Wallace & Tiernan) started operation at Watts pond, Long Island watershed.

1914—September 21—Chlorination of Bayside filter plant effluent, Queens, begun by Electro-bleach machine.

1914—January to August—Test of various types of liquid chlorine machines (Leavitt-Jackson, Wallace & Tiernan and Electro-bleach) at Smith pond, Long Island watershed.

1914—Daily inspection of paths around Oakland lake, Queens, started, due to serious contamination caused by caddies employed by the Oakland Lake Golf Club.

1914—There was difficulty in supplying Long Island City with water so that in January and up to February 5, 3 mgd of water were purchased again from the Citizens Company, in September 1 mgd were obtained from the Urban Water Company, September 30, 1 mgd from the Flushing supply and October 21 to January 26, 1915, 0.7 mgd from operation of Long Island City Station No. 1. In order to spare the Flushing

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supply, Whitestone wells were operated from September 30 to January 23, 1915. The above indicates the complicated supply Long Island City and certain portions of Queens had for years.

1914—During the year Coney Island and portions of the 30th, 31st and 32nd wards of Brooklyn were supplied with water from Gravesend pumping station which had increased in chlorides, hardness and solids to nearly double. The water remained of this character through 1916 and until relieved by Catskill water in 1917.

1914—Reforestation was started on the Brooklyn watershed by the planting of 81,000 trees.

1914—During the year the sketching of premises on the Croton watershed was practically completed (4,000 being accomplished that year).

1914—Examination made of all watershed employees (Croton) by the Diazzo test in attempt to locate any typhoid carriers. No positive tests resulted.

1914—Laboratory division began analysis of urine, feces and blood (Widal) to assist in identification of typhoid cases on the watersheds and also as terminal examination of typhoid patients in order to eliminate carriers.

1915—January 23—Whitestone wells discontinued, Queens.

1915—January 26—Long Island City Station No. 1 dismantled, Queens.

1915—March—New Springville wells (0.9 mgd) supplying 3rd ward, Richmond, discontinued. Replaced by water of Bulls Head wells.

1915—March 18—Started chlorination of remainder of surface supply, Long Island watershed, at Milburn brick conduit (60 mgd).

1915—April—Boulevard auxiliary stations started operation replacing the harder and more saline water of Grant City wells, Borough of Richmond.

1915—July 31—Wallace & Tiernan machine replaced Electro-bleach at Bayside, Queens.

1915—August 6—Started chlorination of West New Brighton well water by liquid chlorine (Wallace & Tiernan machine), Ward 1, Richmond.

1915—December 1—Wallace & Tiernan machine replaced Electro-bleach machine at Valhalla, Bronx pipe-line.

1915—December 27—Catskill water sent to a portion of the Bronx high service.

1915—Kensico reservoir was filled in the winter of 1915-1916 (November 22 to May 21). The inflow of water stirred up mud and caused high turbidity. The water was not used until after the Laboratory division had made a survey and analyzed samples

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1917—February—Liquid chlorine replaced bleach at the chlorination plant on the Kisco river, Croton watershed.

1918—January—Necessary to start Clove pumping station, Richmond.

1918—June 4—Necessary to start Grant City pumping station, Richmond.

1918—June 21—Title taken to South Shore Water Company, Richmond.

1918—New Springville station dismantled and permanently abandoned, Richmond.

1918—Consumption of water increased to 616 mgd average for 1918; Public supplies, two-thirds Catskill (418 mgd), the remainder chiefly Croton. Total consumption, including private companies, 659 mgd.

TABULATED CONSUMPTION, 1918—MGD

Borough	Public	Private	Total	Per Capita
Manhattan	312.3	0.0	312.3	123
The Bronx	101.0	0.0	101.0	
Brooklyn	170.0	13.1	183.1	90
Queens	16.2	30.1	46.3	117
Richmond	16.5	0.0	16.5	162
Totals	616.0	43.2	659.2	112

1918—Clove reservoir, Richmond, surrounded by a man-proof fence to prevent bathing and contamination.

1918—Additional filter bed was built for the Mt. Kisco sewage disposal plant, Croton watershed, and the upper sand renewed on the old beds.

1918—Signs posted on watersheds forbidding bathing. Much of it stopped but infractions could not be prosecuted due to lack of sufficient evidence of pollution, of legal weight.

1918—State rescinded its plan to establish Mohansic State Home for Insane and the Training School for Boys (delinquent) at Yorktown (Croton watershed), changing site to a State park and limiting the farm to 50 persons. The above action due to adoption of policy by City of New York of opposing further additional large institutions on the watersheds.

1918—Recommendations made to establish sewerage systems at Pine Hill, Chichester and Woodland, Catskill watershed, and for Katonah, Bedford Hills, Carmel and extension at Brewster, Croton watershed.

1919—February—Liquid chlorine machine re-established on the Bronx pipe-line, Kensico dam, Valhalla.

1919—August 28—Liquid chlorine machine started operation on

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Clove well water due to surface drainage reaching the well water, Richmond.

1919—May 25 to December 31—Croton water replaced Catskill in the intermediate service of The Bronx borough, 20 mgd.

1919—During the summer months it was necessary, owing to low pressures at Coney Island, to operate Gravesend pumping station (3 mgd) on Saturday, Sunday and Monday each week, Brooklyn.

1919—July 8 to August 29—During the summer it became necessary to pump from the Long Island system at Milburn, 20-23 mgd, chlorinating.

1919—December 30—Automatic dry-feed of copper sulphate at Pleasantville to the Catskill aqueduct first tried and found successful in control of microscopic organisms.

1919—July 28—In order to conserve Catskill water and after experiments with regard to changes of temperature Croton water was introduced again below 14th street, between the hours of 9 P. M. and 5:30 A. M. daily and on Saturday afternoons and Sundays, amounting to 30 mgd.

1919—In the Borough of Richmond, Clove pumping station was in operation the entire year and Grant City pumping station for seven months.

1919—July 29 to August 6—A break in the 48-inch main, Brooklyn, interfered with the supply of Catskill water to Richmond.

1919—July—In Queens, pumpage from the Bayside wells took place for seventeen days during a test.

1919—November 8 to December 31—The Citizens Company supplied Douglaston and Little Neck with 150,000 gallons daily replacing Catskill water.

1919—Bathing notices were not posted during the year.

1919—December 4—Opinion from Corporation Counsel that conviction in bathing cases probably could not be obtained except on City-owned reservoirs.

1919—Plans drawn and request for funds made for a sewage disposal system at Chichester, Catskill watershed.

1919—Plans drawn and request for funds for a liquid chlorine plant to purify St. Mary's Lake brook which received drainage from Bedford Hills, Croton watershed.

1919—Plans drawn and request for funds for extension of the Mt. Kisco sewage disposal plant, Croton watershed.

1919—Village of Mt. Kisco replaced 522 feet of sewer pipe by cast-iron pipe (completed June 4) and built 800 feet new in the "Fish Subdivision".

1919—An extension was made to the trench system of the Montefiore Home sewage disposal system, Croton watershed.

1919—Revised plans were again submitted to the Town of Bedford

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regarding a sewage disposal system and a water supply from Byram lake for Sutton's Row. Negotiations have extended over several years and involve the Village of Mt. Kisco.

1919—Shore fishing permits were discontinued in 1919.

1919—Seven permits were issued for commercial fishing of carp at Croton lake. These fish are said to render water turbid by disturbance of mud.

1919—In the reforestation program there had been planted to date on the Catskill and Croton watersheds the following number of trees:

Croton	800,000
Ashokan	1,515,000*
Kensico	1,352,000*
Hill View	45,000*
Total	3,712,000

The mortality and fire loss have been somewhat high.

1919—Rainfall on the Brooklyn watershed was 53.28 inches, ten inches above normal, and only exceeded twice since 1879.

1919—Hill View reservoir was by-passed in the fall because of contamination by sea-gulls, Catskill system.

1919—Close attention to the results of analyses and conditions on the watershed resulted in a large reduction in the dosage of chlorine at the Dunwoodie and Kensico plants, showing as follows:

	1918 AVERAGE	1919 AVERAGE	MAXIMUM	MINIMUM
Dunwoodie	0.316 ppm†	0.204 ppm	0.350 ppm	0.100 ppm
Kensico	0.198 ppm	0.137 ppm	0.243 ppm	0.077 ppm

Based on current yearly aqueduct flow the saving amounted to 160,000 pounds of chlorine valued at $12,000.

1919—The following table indicates the amounts of water used from the various systems during 1918 and 1919:

SYSTEM	AMOUNT AVAILABLE WITH NORMAL RAIN	AMOUNT USED	
		1918	1919
Catskill	395 mgd	418 mgd	369 mgd
Croton	390 mgd	196 mgd	243 mgd
Brooklyn	150 mgd	.....	3 mgd
Queens	6 mgd	.....	.....
Richmond	14 mgd	2 mgd	4 mgd
Totals	955 mgd	616 mgd	619 mgd

* Planted by Board of Water Supply.
† ppm = parts per million.

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For the sake of convenience the following data have been brought together covering one phase of the development of purification of the supply,—chlorination:

DEVELOPMENT OF CHLORINATION (CITY PLANTS)

TIME	CHEMICAL	SOURCE AND LOCATION
1893—July 1	Electrozone	Brewster sewage; Brewster.
1910—April	Bleach	Mt. Kisco river; Mt. Kisco.
1910—June	Bleach	Croton water; Croton lake screen chamber.
1910—June 24	Bleach	Bronx water; Bronx pipe-line, Valhalla.
1911—June 13	Bleach	Croton water; New Croton aqueduct, Shaft 19, Pocantico Hills.
1911—July 12	Bleach	Brewster sewage; Brewster.
1911—July 12	Bleach	Tonetta brook; Brewster.
1912—July	Bleach	Katonah brook; Katonah.
1912—October 19	Bleach	Smith pond; Smith Pond pumping station, Rockville Center.
1913—May 9	Bleach	Croton water; Old and New aqueducts, Dunwoodie.
1913—June to August	Liquid chlorine test of Lea-vitt-Jackson machine	Long Island water; Ridgewood reservoir, Brooklyn.
1913—September 29	Bleach	Mt. Kisco sewage disposal plant effluent; Mt. Kisco.
1913—October 29	Bleach	Lake Gleneida; Carmel.
1913—November 29	Liquid chlorine Electro-bleach machine	Bronx water; Bronx pipe-line, Valhalla.
1913—December 17	Liquid chlorine Electro-bleach machine	Smith, Pines and Hempstead ponds and Storage reservoir; Smith Pond pumping station, Rockville Center.
1914—January-August	Liquid chlorine test of Lea-vitt-Jackson, Electro-bleach and Wallace & Tiernan machines	Smith, Pines and Hempstead ponds and Storage reservoir; Smith Pond pumping station, Rockville Center.
1914—July 21	Liquid chlorine (Wallace & Tiernan) replaced (Electro-bleach)	Smith, Pines and Hempstead ponds and Storage reservoir; Smith Pond pumping station, Rockville Center.
1914—September 19	Liquid chlorine (Wallace & Tiernan)	Watts and Valley Stream ponds; Watts Pond pumping station, Valley Stream.
1914—September 21	Liquid chlorine (Electro-bleach)	Oakland lake, filtered; Bayside.
1915—March 18	Liquid chlorine (Wallace & Tiernan)	Long Island watershed-East; conduit, Milburn pumping station, Baldwins.
1915—July 31	Liquid chlorine (Wallace & Tiernan) replaced (Electro-bleach)	Oakland lake, filtered; Bayside.
1915—August 6	Liquid chlorine (Wallace & Tiernan)	West New Brighton wells; West New Brighton, Richmond.
1915—December 1	Liquid chlorine (Wallace & Tiernan) replaced (Elec-tro-bleach)	Bronx water; Bronx pipe-line, Valhalla.
1916—April 4	Liquid chlorine (Wallace & Tiernan)	Croton water; Dunwoodie.
1916—June 18	Liquid chlorine (Wallace & Tiernan)	New York State Reformatory for Women; Sewage disposal plant effluent, Bedford.
1916—August 23	Liquid chlorine (Wallace & Tiernan)	Bronx water; Bronx pipe-line, WHliamsbridge.
1916—December 25 to 1917—January 22	Liquid chlorine (Wallace & Tiernan)	Croton water; Shaft 23, Brooklyn.
1917—February	Liquid chlorine (Wallace & Tiernan) (replaced bleach)	Mt. Kisco river; Mt. Kisco.
1917—March 19 to April 15	Liquid chlorine (Wallace & Tiernan)	Catskill water; Catskill aqueduct, Valhalla.
1917—June 21	Liquid chlorine (Wallace & Tiernan (Injection sys-tem)	Catskill water; Catskill aqueduct, Valhalla.
1917—October 10	Bleach	Esopus creek; Phoenicia.
1919—February	Liquid chlorine (Wallace & Tiernan) (re-established)	Bronx water; Bronx pipe-line, Valhalla.
1919—August 28	Liquid chlorine (Wallace & Tiernan)	Clove wells; Clove pumping station, Richmond.

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That the attention given to the sanitation of New York City's water supply has improved the quality of the water is without question. In order to present this in tabular form the average analyses for B. coli have been calculated by boroughs and compared with the typhoid death rate for the Boroughs of Manhattan, The Bronx and Brooklyn. The well supplies of Queens and Richmond were too varied to calculate in this manner. The following table presents the above data:

ANALYSES FOR B. COLI COMPARED WITH TYPHOID DEATH RATE
(Covering the last two decades)

Year	Supply	Proportion	B. coli—Per Cent. 0.1–1.0–10cc.	B. coli Per 10cc.		Typhoid Death-Rate Per 100,000 Population
			Manhattan Borough			
1900	Croton	...	.....	....		18.4
1901	Croton	...	.....	....		20.0
1902	Croton	...	.....	....		18.7
1903	135th G. H.	...	9.7–19–27	11.87		15.8
1904	135th G. H.	...	3.3–12–23	4.73		13.4
1905	135th G. H.	...	4.3–16–33	6.23		12.9
1906	135th G. H.	...	2.9–14–48	4.78		14.9
1907	135th G. H.	...	0.9– 8–52	2.22		16.7
1908	135th G. H.	...	0.8– 4–36	1.56		11.1
1909	135th G. H.	...	1.4–12–42	3.02		11.0
1910	135th G. H.	...	7.5–24–59	10.49		11.5
1911	135th G. H.	...	4.8–30–76	8.56		10.8
1912	135th G. H.	...	1.1–10–44	2.54		7.9
1913	135th G. H.	...	0.3– 3–23	0.83		7.2
1914	135th G. H.	...	3.8–12–39	5.39		5.9
1915	135th G. H.	...	1.1– 7–27	2.07		5.3
1916	135th G. H.	...	0.3– 2–19	0.69		3.3
1917	Croton Dun. Cl.	*	0.3– 2–10	0.60	0.64	3.6
	Catskill Ken. Cl.	†	0.6– 1– 2	0.72		
1918	Croton Dun. Cl.	3/5	0.3– 1– 9	0.49	0.27	3.1
	Catskill Ken. Cl.	2/5	0.0– 0– 4	0.04		
1919	Croton Dun. Cl.	3/5	0.3– 1– 4	0.44	0.25	1.8
	Catskill Ken. Cl.	2/5	0.0– 0– 6	0.06		
			Bronx Borough			
1900		...	.....	....		14.9
1901		...	.....	....		14.9
1902		...	.....	....		14.9
1903	Croton, 135th G. H.	2/5	9.7–19–27	11.87	7.09	13.6
	Bronx, Williamsbridge	3/5	2.3–14–21	3.91		
1904	Croton	2/5	3.3–12–23	4.73	1.93	12.5
	Bronx	3/5	0.0– 0– 6	0.06		
1905	Croton	1/2	4.3–16–33	6.23	4.54	13.6
	Bronx	1/2	1.9– 8–14	2.84		
1906	Croton	1/2	2.9–14–48	4.78	2.72	15.2
	Bronx	1/2	0.0– 4–26	0.66		
1907	Croton	4/7	0.9– 8–52	2.22	1.50	15.6
	Bronx	3/7	0.0– 2–34	0.54		
1908	Croton	4/7	0.8– 4–36	1.56	1.33	11.3
	Bronx	3/7	0.0– 8–23	1.03		
1909	Croton	4/7	1.4–12–42	3.02	2.69	17.0
	Bronx	3/7	0.0–17–54	2.24		
1910	Croton	2/3	7.5–24–59	10.49	8.09	9.3
	Bronx	1/3	1.9– 8–58	3.28		
1911	Croton	2/3	4.8–30–76	8.56	6.30	7.9
	Bronx	1/3	0.0–12–58	1.78		
1912	Croton	3/4	1.1–10–44	2.54	2.62	4.9
	Bronx	1/4	0.0–21–75	2.85		

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Year	Supply	Proportion	B. coli—Per Cent. 0.1–1.0–10cc.	B. coli—Per 10cc.		Typhoid Death-Rate Per 100,000 Population
			Bronx Borough (*Concluded*)			
1913—	Croton	3/4	0.3– 3–23	0.83	1.85	5.3
	Bronx	1/4	1.9–23–69	4.89		
1914—	Croton	3/4	3.8–12–39	5.39	5.59	4.7
	Bronx	1/4	3.8–19–58	6.28		
1915—	Croton	3/4	1.1– 7–27	2.07	3.52	4.2
	Bronx	1/4	5.8–15–56	7.86		
1916—	Croton	1/2	0.3– 2–19	0.69		
	Catskill, Will'msbridge	1/4	0.0– 5–12	0.62	0.62	4.0
	Catskill, Shaft 23	1/4	0.3– 1– 8	0.48		
1917—	Croton, Dun. Cl.	1/2	0.3– 2–10	0.60	0.66	4.5
	Catskill, Ken. Cl.	1/2	0.6– 1– 2	0.72		
1918—	Croton	1/2	0.3– 1– 9	0.49	0.27	2.6
	Catskill	1/2	0.0– 0– 4	0.04		
1919—	Croton	1/2	0.3– 1– 4	0.44		
	Catskill	1/2	0.0– 0– 6	0.06	0.25	1.7
			Brooklyn Borough			
1900—		...	.....	.....		25.7
1901—		...	.....	.....		22.6
1902—		...	.....	.....		25.9
1903—	Ridgewood Inf., Long Island System	...	4.0–16–27	5.87		20.8
1904—	Ridgewood Inf.	...	1.9–12–26	3.36		22.9
1905—	Ridgewood Inf.	...	3.9–18–36	6.06		21.8
1906—	Ridgewood Inf.	...	3.4–12–46	5.06		16.4
1907—	Ridgewood Inf.	...	0.2– 3–41	0.91		18.7
1908—	Ridgewood Inf.	...	1.5–11–41	3.01		13.8
1909—	Ridgewood Inf.	...	1.9–11–42	3.42		12.0
1910—	Ridgewood Inf.	...	0.8– 9–39	2.09		12.0
1911—	Ridgewood Inf.	...	1.7–10–43	3.13		12.3
1912—	Ridgewood Inf.	...	1.9–13–47	3.67		13.0
1913—	Ridgewood Inf.	...	1.5– 8–35	2.65		6.6
1914—	Ridgewood Inf.	...	0.0– 4–29	0.69		6.4
1915—	Ridgewood Inf.	...	0.3– 3–17	0.77		7.6
1916—	Ridgewood Inf.	...	0.1– 1– 8	0.28		3.9
1917—	Tap Samples‡	...	0.2– 1–14	0.44		4.1
1918—	Shaft 23, Catskill	...	0.0– 0– 2	0.02		4.0
1919—	Shaft 23, Catskill	...	0.0– 3–17	0.47		2.1

* All for 3 months; three-fifths for 9 months.
† None for 3 months; two-fifths for 9 months.
‡ Three months Long Island and nine months Catskill.

In order to compare visually the above data, diagrams have been prepared for Manhattan, The Bronx and Brooklyn boroughs (Diagrams 1, 2, and 3, respectively), showing the typhoid and diarrhœal death-rates for the last two decades and the B. coli content of the water supply since 1903, as the Laboratory division analyses for Manhattan and The Bronx began in 1903 and the analyses made on the Brooklyn supply previous to 1903 were not comparable. Diagrams 4 and 5, representing Queens and Richmond, respectively, are also included, although the B. coli content could hardly be included owing to the diversity and number of separate supplies. Diagram 6 is also included showing the typhoid death-rate, diarrhœal death-rate and the general death-rate for the entire City.

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There appears to be no definite correlation between the B. coli content in the first three diagrams and the typhoid and diarrhœal curves. The two latter appear to conform in a general way one to the other. While all the data is given in the general tables of improvement of the water supply, it seems advantageous to briefly state in connection with each chart the main features.

Manhattan Borough—Diagram 1

1903—Laboratory analyses and supervision begun.

1907—Water epidemic occurred in the spring.

1910—Survey of watersheds by committee representing Health, Law and Water. Bleach treatment first used crudely in June.

1911—Continuous bleach treatment started at Pocantico in June. Chlorination of Mt. Kisco river started in April. Low rainfall on the watershed.

1912—Chlorination of Katonah brook started in July. Deep draft at Croton lake begun. Reforestation begun. Water very turbid in the spring for several weeks.

1913—Bleach treatment transferred to Dunwoodie, May 9. Mt. Kisco sewage disposal plant began operation in February; Chlorination of the effluent began September 29. Chlorination of Lake Gleneida begun. Laying out of inspection districts. Mapping and indexing of sources of pollution. Cleaning of highway bridges. Closing of train toilets. Excess flow on the watershed.

1914—Typhoid examinations on watershed begun by Laboratory division.

1916—Liquid chlorine replaced bleach at Dunwoodie in April. New sewage disposal plant started operation in January at the New York State Reformatory for Women, at Bedford. Stopping of boating on reservoirs for period of war.

1917—Catskill water supplied to two-fifths of borough. Bleach plant at Phœnicia started operation in October.

1918—Overhauling of Mt. Kisco sewage disposal filter beds.

The Bronx Borough—Diagram 2

1903—Beginning of analyses by Laboratory division.

1909—High rate due to milk epidemic.

1910—Bleach treatment of Bronx supply started June 24.

1911—Bronx dike put into operation.

1912—Water turbid in the spring.

1913—Liquid chlorine replaced bleach on Bronx pipe-line November 29.

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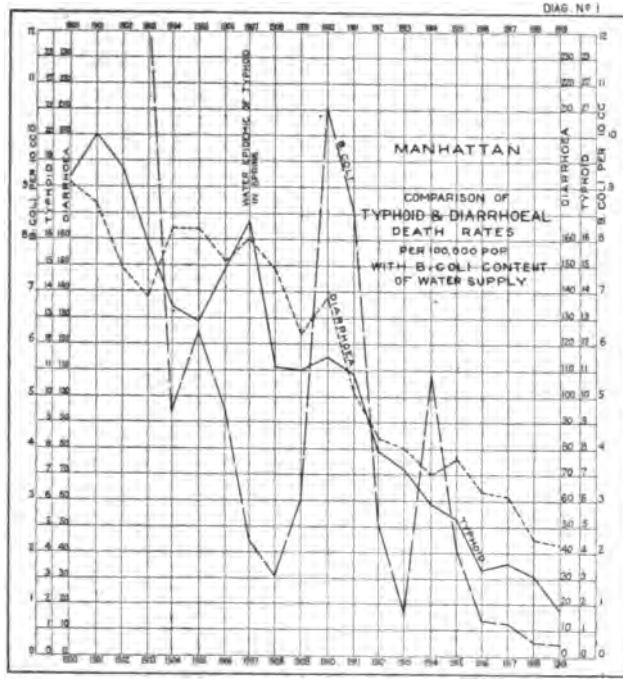
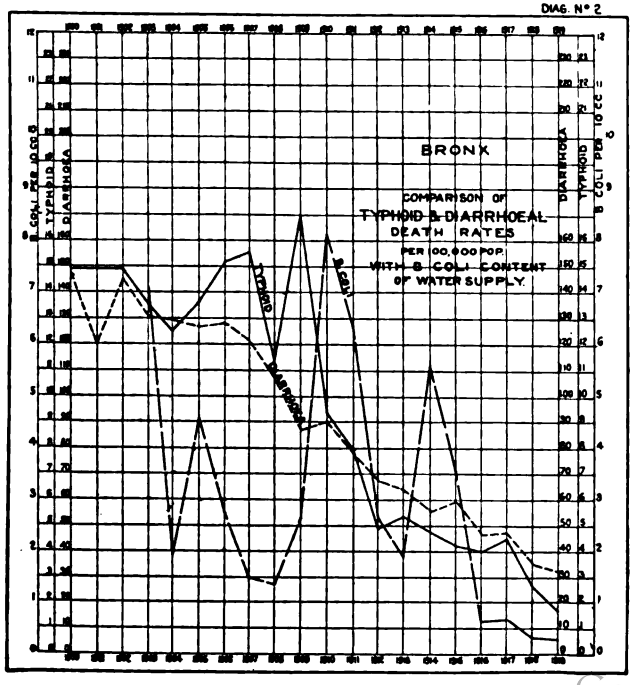
DIAG. N° 1



DIAG. N° 2



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1916—Catskill water supplied one-half of borough.

1917—Chlorination of Catskill water begun at Kensico. In addition all of the statements made regarding the Croton supply apply to The Bronx borough since the Croton water supplied a large portion of the borough.

Brooklyn Borough—Diagram 3

1897—Laboratory division started analyses and supervision.

1910—Survey of watershed by committee of Health, Law and Water. Lower rainfall on the watershed.

1912—Water turbid in the spring. Bleach treatment of Smith pond started October 19.

1913—Liquid chlorine treatment of Smith, Hempstead and Pines ponds and Storage reservoir begun December 17.

1914—Liquid chlorine treatment of Watts and Valley Stream ponds begun September 19. Reforestation begun.

1915—Liquid chlorine applied at Milburn pumping station March 18.

1916—Severe drought on watershed.

1917—Croton water sent to Brooklyn in January. Catskill water introduced, replacing entire supply by April.

Queens Borough—Diagram 4

1897—Laboratory division started analyses and supervision.

1911—Bayside filter plant began operation August 14. Long Island City pumping stations Nos. 1 and 3 shut down and No. 2 abandoned.

1913—Long Island water replaced well water in Long Island City.

1914—Liquid chlorine applied to effluent at Bayside filter plant September 21. Long Island water replaced in Long Island City by well water during the fall. Daily inspection of Oakland lake begun.

1917—Introduction of the Catskill supply to Wards 1 and 3.

Richmond Borough—Diagram 5

1903—Laboratory analyses and supervisions begun.

1907—Water epidemic at West New Brighton.

1910—City acquired Crystal and Staten Island water companies.

1912—Boulevard temporary plant started operation.

1915—New Springville pumping station discontinued, beginning March. Boulevard auxiliary plants started in April.

1916—New Springville pumping station in operation during the fall.

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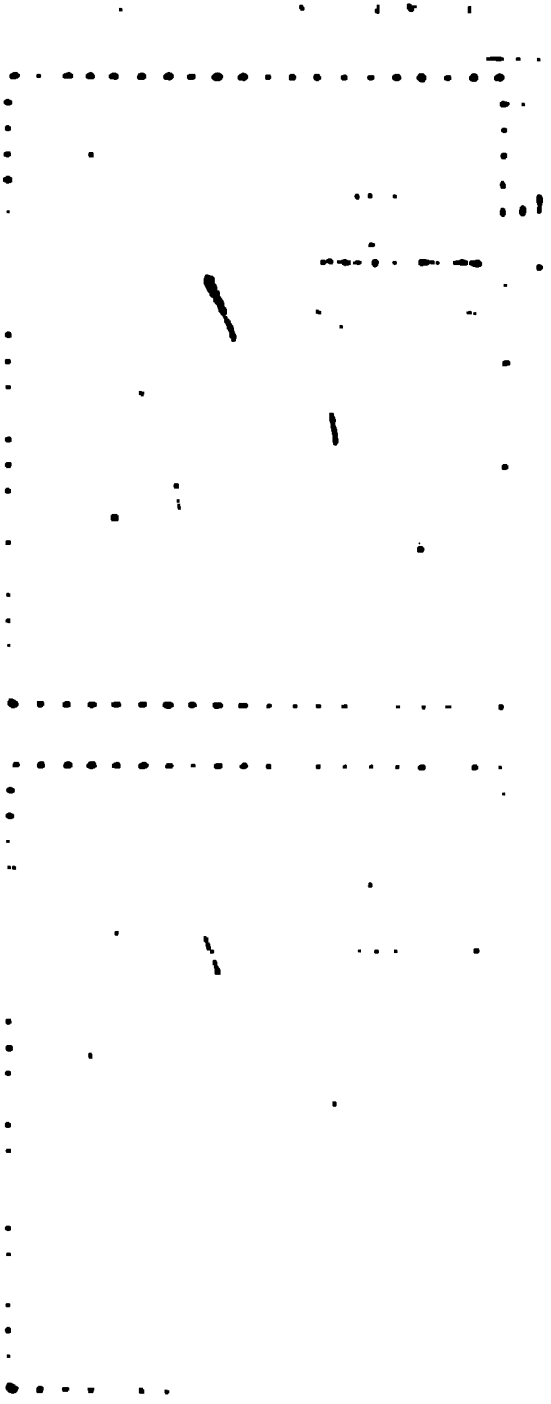

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1917—Introduction of Catskill water, replacing well water.

1918—Clove reservoir fenced. Clove and Grant City pumping stations again started operation.

1919—Liquid chlorine applied to Clove well water beginning August.

If the improvement in the water supply has had any definite effect upon the typhoid death rate, it is felt that there are several instances in which the improvement should have had immediate effect rather than a gradual lowering of the death rate, for example the introduction of chlorination, the introduction of Catskill water, etc. These instances will be studied in detail in the following:

Manhattan Borough

1910—June—Start of temporary bleach treatment, crudely performed by shoveling dry bleach at frequent intervals into the New aqueduct at Croton Lake screen chamber. Treatment at intervals during the year.

1911—June—Continuous bleach treatment of New aqueduct begun at new plant, Shaft 19, Pocantico Hills.

1909	11.0*
1910	11.5
1911	10.8
1912	7.9

No apparent effect during years treatment started although it was carried on throughout the fall, the period of highest typhoid cases. A reduction does appear the year following.

1913—May 9—Treatment shifted to new bleach plant, Dunwoodie, including Old aqueduct as well as New.

1912	7.9
1913	7.2
1914	5.9

No appreciable effect during the year. A reduction did occur the year following.

1916—April 4—Liquid chlorine substituted for bleach at Dunwoodie.

1915	5.3
1916	3.3
1917	3.6

There was a decided reduction in typhoid during the year although

* Figures in this column indicate typhoid death rate per 100,000 population.

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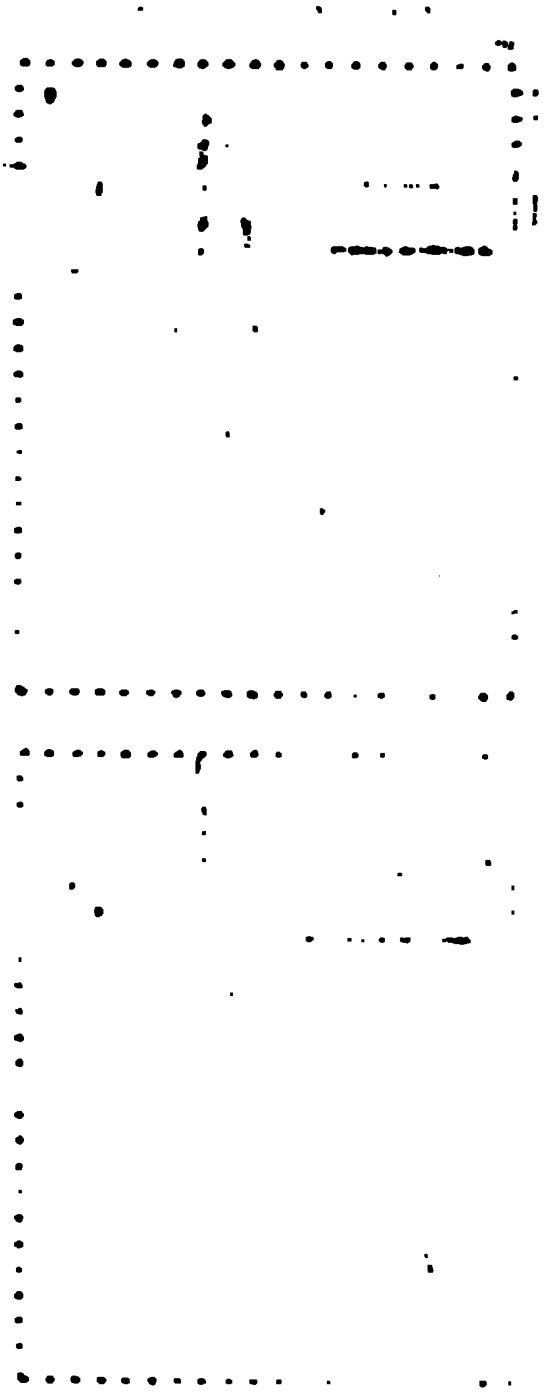

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no effect was indicated in The Bronx borough as will be shown under that borough.

1917—April—Chlorinated Catskill supply introduced to about four-sevenths of Manhattan borough, replacing Croton water. Supply chlorinated March 19 to April 15, and after June 21, continuously.

1916	3.3
1917	3.6
1918	3.1

No apparent effect.

Bronx Borough

Water from both the Croton and Bronx watersheds supplied this borough.

1910—June—Croton water treated at intervals by dry bleach at Croton Lake screen chamber, New aqueduct (approximately two-thirds of The Bronx Borough supply).

1910—June 24—Started bleach treatment of Bronx watershed, Bronx pipe-line, Valhalla (approximately one-third of supply to the borough).

1908	11.3
1909	17.0
1910	9.3
1911	7.9

The rate for 1909 was abnormally high due to a milk epidemic definitely traced to a carrier.

There was a reduction in the typhoid rate during the year and the year following.

1911—June—Continuous treatment of Croton supply at Poncantico Hills started (two-thirds of The Bronx Borough supply).

1910	9.3
1911	7.9
1912	4.9

There was a reduction in the typhoid rate during the year and the year following.

1913—May 9—Bleach treatment of Croton water changed to Dunwoodie (three-quarters of The Bronx Borough supply).

1913—November 29—Liquid chlorine replaced bleach in treatment of Bronx pipe-line, Valhalla (one-quarter of The Bronx supply).

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1912	4.9
1913	5.3
1914	4.7

No apparent effect.

1915—December 27—Catskill water sent to The Bronx borough, the supply of which was approximately as follows: In 1915, three-quarters Croton, one-quarter Bronx; in 1916, one-half Croton, one-half Catskill.

1916—April 4—Liquid chlorine replaced bleach in treatment of Croton water at Dunwoodie.

1915	4.2
1916	4.0
1917	4.7

No apparent effect.

1917—March 9 to April 15 and after June 21—Chlorination of Catskill supply by liquid chlorine at Kensico, Catskill aqueduct (approximately one-half borough supply).

1916	4.0
1917	4.7
1918	2.6

No effect during the year. There was a reduction in typhoid the year following but no such effect was noticeable in any other borough upon the introduction of the Catskill supply.

Brooklyn Borough

1912—October 19—Bleach applied to effluent of Smith pond (approximately 8 mgd, or one-twentieth of supply).

1911	12.3
1912	13.0
1913	6.6

No effect during the year. The drop the year following could hardly be due to the chlorination of so small a portion of the borough supply. The reduction in 1913 was probably due to pasteurization of milk introduced that year.

1913—December 17—Liquid chlorine applied to brick conduit at Smith Pond pumping station covering surface supplies of Smith, Hempstead and Pines ponds and Storage reservoir (approximately 16 mgd, or one-tenth of supply).

1913	6.6
1914	6.4

No apparent effect.

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1914—September 19—Liquid chlorine applied at Watts Pond pumping station to Watts and Valley Stream ponds (approximately 5 mgd, or one-thirtieth of supply).

1913	6.6
1914	6.4
1915	7.6

No effect.

1915—March 18—Liquid chlorine applied to brick conduit at Milburn pumping station (60 mgd, or two-fifths of borough supply).

1914	6.4
1915	7.6
1916	3.9

No effect during the year although chlorination was applied during 9½ months of 1915. There was a decrease in typhoid the year following.

1917—January to March—Introduction of chlorinated Catskill supply to Brooklyn borough replacing Long Island water. About 90 mgd to low service at first, increasing to entire displacement by April.

1916	3.9
1917	4.1
1918	4.0

No effect.

QUEENS BOROUGH

1911—August 14—Bayside filter plant put in operation supplying part of Ward 3, Flushing, etc., 1.5 mgd.

	WARD 3— (ONE-THIRD SUPPLY)	BOROUGH (ONE-THIRTY-FIFTH SUPPLY)
1910	16.0	13.5
1911	3.0	9.0
1912	10.0	14.4

1915—July 31—Liquid chlorine applied to effluent of Bayside filter plant.

	WARD 3— (ONE-THIRD SUPPLY)	BOROUGH (ONE-THIRTY-FIFTH SUPPLY)
1914	10.0	6.2
1915	0.0	5.3
1916	5.0	5.7

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In both instances the typhoid rate of the ward was decidedly lower during the year and also considerably lower the year following. The population affected was probably too small to influence the borough figures.

As Oakland lake has been subject to serious human contamination it is possible that the introduction of filtration and chlorination may have had a direct effect upon the typhoid rate of the 3rd ward.

1913—May 21—Long Island water sent to Long Island City—3 mgd.

1913—June 15—Long Island water sent to Long Island City—7 mgd.

	Ward 1 One-Quarter to One-Half Supply	Borough One-Sixteenth to One-Seventh Supply
1912	9.0	14.4
1913	12.0	6.7
1914	11.0	6.2

(In 1914, Long Island water was replaced in January and in the fall by well supplies again temporarily).

No effect upon the ward, and consequently there could be none upon the borough. The decrease in the borough may have been due to pasteurization of milk introduced in 1913.

1917—April—Chlorinated Catskill water sent to Queens borough, Wards 1 and 3, 18.5 mgd (two-fifths borough supply).

1916	5.7 for borough
1917	5.0 for borough
1918	2.3 for borough

No appreciable effect during the year. There was a drop the following year.

Richmond Borough

1917—April—Chlorinated Catskill water introduced. Complete change from ground sources to surface sources.

1915	6.0
1916	8.2
1917	6.0
1918	5.9
1919	5.8

No apparent effect.

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To summarize, in the above nineteen specific instances there were eight cases in which there was no apparent effect upon the typhoid rate and five cases in which there was no effect during the year the change took place. In six cases there was a decrease in typhoid fever during the year and five cases the year following. In some of the instances in which a decrease occurred such decrease was not shown in another borough supplied by the same water.

There have been two instances in which epidemics of typhoid fever within the City have been due, it is believed, to the water supply, as follows:

In Richmond, in the fall of 1907, an epidemic occurred in the section supplied by the West New Brighton pumping station, then operated by the Staten Island Water Company. The Laboratory division ascertained definitely by analyses that water from Palmers Run, a brook running through the premises and connected up to the station for the purpose of boiler supply, was mixed with the well supply. The pipe conveying the brook supply to the station was sealed off by the Department of Water Supply and seventeen days later the epidemic stopped abruptly with the exception of a very few secondary cases.

In the spring of 1907 an epidemic of typhoid fever occurred at Katonah, on the Croton watershed. This was followed by a spring rise in typhoid in Manhattan borough equal in size to the normal fall rise. Likewise the distribution of the cases was entirely different from that of the fall rises,—that is, during the spring rise the cases were distributed throughout the center of the borough, heaviest in the northern section and decreasing to the south. The distribution in the fall rise is along the water-front and heaviest in the southern part of the borough. It was learned that the well supply of Katonah had mixed with it for a short period water from Beaver Dam brook just previous to the epidemic in that village. It is probable that contamination of this brook caused the local epidemic and either also contaminated the City's supply or the latter became contaminated by drainage from the village.

With the exception of the above two instances it has been believed by the officials of the Water Department that the water supply has had no connection with typhoid fever during the last two decades. The following general considerations support this view:

The typhoid rates of the several boroughs have been similar and the general trend of improvement considerably alike and yet the

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various borough supplies have been from entirely different sources and of entirely different character,—for example, Richmond and Queens were supplied from a considerable number of individual well groups, Brooklyn had a mixture of surface and well waters on the Long Island watershed and also individual well supplies, Manhattan had the surface water of the Croton supply and The Bronx had the surface waters of the Croton and Bronx watersheds besides at times in the early part of the former decade water from the Yonkers supply, the New Rochelle Water Company and the Westchester Water Company.

The typhoid curve of cities with pure water supply normally shows only the fall rise or, as in certain European cities, a straight line throughout the year. Cities with bad water supply show abrupt changes with rises particularly in the winter and spring. The curve for New York City, with the exception of the year 1907, shows only the fall rise.

The distribution of cases in Manhattan and The Bronx should be, as in the epidemic of 1907, heaviest from north to south if the typhoid fever were due to water supply. The distribution is, however, not so distributed. Moreover, the cases have been heaviest along the water-front and in localized sections.

It seems probable that chlorination has had no direct effect in the reduction of typhoid fever, since any such effect should have been sudden and noticeable.

The entire change in the water supply of the Boroughs of Brooklyn, Queens and Richmond and a large part of Manhattan and The Bronx, occurring when the Catskill supply was introduced, had no effect upon the typhoid rate.

It seems probable that the reduction in typhoid fever in New York City, which has been almost along a straight line during the last twenty years, has been due to various other factors than water supply, for example:

Complete pasteurization of milk (1913); Immunization of the exposed by anti-typhoid serum (1913); The search for carriers (one per cent. of all cases developing into such); (Massachusetts statistics, in a recent article, show that 10 per cent. of typhoid cases were directly traced to the milk supply and the majority of these to carriers among the milk workers); Improvement in sewage disposal locally and generally; Fly propaganda; Attention to oysters; General nation-wide improvement reducing the number of carriers

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and local foci,—For instance, the improvement in the water supply of Niagara Falls (a summer resort) must have prevented the dissemination of considerable latent typhoid.

The following table contains the typhoid death-rate per 100,000 population by boroughs and for the Greater City from 1900 to 1919, inclusive:

Year	Manhattan	Brooklyn	The Bronx	Queens	Richmond	Greater New York
1900....	18.4	25.7	14.9	20.8	19.4	20.8
1901....	20.0	22.6	14.9	16.7	23.4	20.5
1902....	18.7	25.9	14.9	15.8	15.9	20.8
1903....	15.8	20.8	13.6	12.3	19.8	17.3
1904....	13.4	22.9	12.5	18.0	20.9	16.9
1905....	12.9	21.8	13.6	15.6	15.1	16.1
1906....	14.9	16.4	15.2	14.3	13.5	15.4
1907....	16.7	18.7	15.6	16.3	17.2	17.3
1908....	11.1	13.8	11.3	13.8	9.1	12.1
1909....	11.0	12.0	17.0	16.0	14.0	12.4
1910....	11.5	12.0	9.3	13.5	12.7	11.6
1911....	10.8	12.3	7.9	9.0	12.3	10.9
1912....	7.8	13.0	4.9	14.4	2.2	9.7
1913....	7.2	6.6	5.3	6.7	5.2	6.7
1914....	5.9	6.4	4.7	6.2	4.0	5.9
1915....	5.3	7.6	4.2	5.3	6.0	6.0
1916....	3.3	3.9	4.0	5.7	8.2	3.8
1917....	3.6	4.1	4.5	5.0	6.0	4.0
1918....	3.1	4.0	2.6	2.3	5.9	3.3
1919....	1.8	2.1	1.7	2.5	5.8	2.0

The following table contains the diarrhœal death-rate per 100,000 population by boroughs and for the Greater City from 1900 to 1919, inclusive:

						Greater New York	
Year	Manhattan	Brooklyn	The Bronx	Queens	Richmond	Total	Over 5 Years
1900....	182	230	148	212	212	198	25
1901....	174	225	120	202	234	191	20
1902....	149	167	145	169	225	157	15
1903....	138	136	100	128	191	135	18
1904....	164	176	129	175	219	167	25
1905....	164	167	127	182	234	165	13
1906....	151	160	128	193	229	156	12
1907....	160	176	121	185	224	165	12
1908....	148	151	107	157	215	148	10
1909....	124	129	87	148	142	124	8
1910....	138	137	90	135	131	133	10
1911....	102	111	78	105	134	103	8
1912....	84	97	67	104	128	89	7
1913....	80	79	63	89	89	78	7
1914....	70	76	55	94	76	72	5
1915....	76	82	59	85	92	77	5
1916....	63	57	46	59	65	59	4
1917....	62	66	47	68	84	63	5
1918....	45	53	34	45	62	47	4
1919....	43	47	32	47	66	44	..

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In the Burr-Hering-Freeman Report on Additional Water Supply —1903, pages 306-321, will be found typhoid statistics as to New York City from 1868 to 1902, inclusive, including comments, death-rate by boroughs and diagram.

4. *What changes in the water supply have occurred which had marked influence on the morbidity or mortality of Greater New York aside from consideration included under Questions* 1, 2 *and* 3, *above mentioned?*

It is felt that the statistics given under the three previous questions have fully answered this question. If there is anything in the Hazen Theorem that three lives are saved for every one death prevented from typhoid fever by filtration of the water supply it would likewise seem probable that a similar beneficial effect would be accomplished by any general improvement in water supply.

In the paper on "Safeguarding the Water Supply of New York City"* will be found a list of references which may be useful in this connection. Particular attention is also called to the sections in the paper entitled Sewage Disposal (page 123.17), Chlorination (page 123.22) and Typhoid Fever (page 123.27).

* JOURNAL, Municipal Engineers of the City of New York, May–June, 1919.

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TABLE 1—ANALYSES CORRESPONDING TO CHANGES IN WATER SUPPLY

Year	Date	Bor.	Section supplied. Ward	Pop.	Water Supply changed. From	To	Hardness as ppm. $CaCO_3$ changed From	To	Alkalinity as ppm. $CaCO_3$ changed From	To	Nitrate as ppm. N changed From	To	Chloride as ppm. Cl changed From	To	Solids ppm. changed From	To	Microscopic organisms units per cc changed From	To	Bacteria per cc. (37°C) changed From	To	B. coli changed percent in cc. .1 From	cc. 1. To	cc. .1 From	cc. 1. To
1909	Aug.10	Bk.	Canarsie Note 1.	15,000	Long Island.	Canarsie Wells.	86	100	18	60	1.25	4.40	13.0	9.0	90	180	500	0	250	28	0--5--28		0--0--0	
"	Fall	"	Coney Island 30-31-32	50,000	Increased pumpage Gravesend Wells		107	133	60	63	4.32	5.06	24.4	42.0	190	240	0	0	70	330	0--0--12		2-11-21	
1910	Feb.16	"	Note 2.	400,000	Long Island.	Forest Pk.Wells	361	50 177	18	29 127	1.25	1.75 6.20	13.0	12.8 10.5	90	106 253	500	0	250	130 117	0--5--28		0--3--9	
"	....	Rich.	North Shore 1 & 3	30,000	Increased pumpage W.N.B.Wells (Note 3)		376	496	94	97	2.51	2.39	371.8	580.3	1022	1436	0	0	451	128	0-20--20		0--9--9	
"	....	"	2 & 4	15,000	Increased pumpage Grant City Wells		160	246	86	89	1.53	1.48	54.5	139.9	262	466	0	0	37	18	0--0---0		0--0--0	
"	Feb.18	Bk.	30 - 31	10,000	New Utrecht Wells	Gravesend Wells	210	135	63	63	3.35	5.06	200.0	42.0	520	240	0	0	150	330	0-10--20		2-11-21	
"	Apr.15	"	East of Gowanus Canal	25,000	Titus-6th St. Wells	Long Island	220	40	150	18	4.00	1.40	40.-100.0	17.0	360	106	0	515	3500	285	0--1---6		0--7-38	
"	Apr.30	Q.	Steinway 1st	6,000	North Beach Wells	L.I.City #2 Citizens #2	270	325 255	150	180 140	9.50	16.40 12.20	80.0	41.5 17.1	510	530 405	0	0	75	95 20	0--6--17	0-30-70	0--0--0	
"	Aug.11	Rich.	3rd	3,000	Linoleumville Wells	Bulls Head Wells	156	116	91	104	3.03	.45	17.5	8.6	256	178	0	0	2827	240	17-33-50		0--0--0	
1911	....	Bk.	Coney Island 30-31-32	50,000	Changed character Gravesend Wells		133	170	63	61	5.05	3.65	42.0	77.9	240	343	0	0	330	13	2-11-21		0--0--6	
"	Sep.18	Q.	Whitestone 3rd	4,000	Whitestone Wells	Flushing P.S. (Note 6.)	115	60	85	31	2.54	4.05	8.5	9.3	182	132	0	0	195	95	14-38-57		2-16-45	
"	Oct. 3	"	L.I.City 2nd	10,000	L.I.City #1 " " #3	Urban Wells	173 271	208	103 175	118	4.16 4.48	10.00	19.5 26.4	26.3	302 455	340	0 0	0 0	675 130	5	0-50-100 0--0-75		0--0--8	
"	Dec. 6	"	Steinway 1st	2,000	L.I.City #2 Wells	Citizens #2 Wells	314	280	173	145	15.93	10.20	38.8	17.8	510	433	0	0	95	6	0--6-50		0--0-25	
1912	Jan.17	Rich.	2 & 4	9,000	Grant City Wells	Boulevard Wells Temp.Sta.	216	147	86	118	1.31	.84	(Note 4) 119.9	11.2	433	180	0	0	28	11	0--0--0		0--0--0	
"	Mar.15	Bk.	26	25,000	New Lots Old Wells	New Lots New Wells	208	161	114	108	12.17	6.03	25.6	18.0	357	256	0	0	94	8	0--0--0		0--0--0	
"	Sep.	Rich.	Int.Service 2nd	5,000	Clove Wells	Grant City Mixture	140	182	104	93	.75	2.35	7.0	82.0	147	359	0		57	68	0--8--8		8-25-54	

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Year	Date	Bor.	Section supplied Ward	Pop.	Water Supply changed From	To	Hardness as ppm. $CaCO_3$ changed From	To	Alkalinity as ppm $CaCO_3$ changed From	To	Nitrate as ppm. N_2O_5 changed From	To	Chloride as ppm. of Cl changed From	To	Solids ppm. changed From	To	Micro-scopic Organisms units per cc. changed From	To	Bacteria Per cc. (37°C) changed From	To	B. coli per cent in .1 c.c. 1 c.c. 10. c.c. changed From	To
1916	Dec.31	Rich.	3rd	9,000	New Springville Wells	Catskill	164	80	77	16	0.25	.09	18.6	1.6	344	47	0	240	44	8	0--0--25	0--4--21
"	Oct.	Bk.	Local 26	6,000	German-American Wells	Long Island	253	44	116	14	5.07	1.02	88.8	30.0	467	130	55	25	6	9	0--0--0	0--1--9
"	Nov.29	Rich.	St.George 1st.	(Note 9)	Mixture 3d Ave. Reservoir	do.	202	44	100	14	1.10	1.02	123.0	30.0	438	130	..	25	20	9	0--0--0	0--1--9
"	Dec.27	Bk.	Borough Hall Section	175,000	(Note 10) Long Island	Croton	44	32	14	91	1.02	.25	30.0	33.0	130	310	25	0	9	4	0--1--9	0--0--0
1917	Jan.22	Bk.	Low Service	1,000,000	Croton and Long Island	90 Mgd. Catskill	37 44	20	36 14	16	.20 1.02	.09	8.2 30.0	1.6	80 130	47	0 25	240	9 9	8	0--0--6 0--1--9	0--4--21
"	Mar.	Q.	North Beach	700	North Beach Wells	Catskill	392	18	158	14	0.80	.11	74.3	1.8	522	38	0	206	51°	5	0--0--50	0--4--14
"	Apr.	Man.	(Note 11)	1,300,000	Croton	Catskill	38	17	31	13	.18	.08	3.9	1.8	72	42	335	265	18	8	0--2--19	0--4--21
"	Apr.13	Bk.	General	1,880,000	Long Island	Catskill	44	17	14	13	1.02	.08	30.0	1.8	130	42	25	265	9	8	0--1--9	0--4--21
"	Apr.	Bk.	Coney Island 30-31-32	80,000	Gravesend Wells	Catskill	320	17	88	13	2.66	.08	266.8	1.8	734	42	0	265	3	8	0--0--0	0--4--21
"	Apr.	Bk.	Canarsie (Note 1)	30,000	Canarsie Wells	Catskill	152	17	61	13	4.30	.08	51.5	1.8	269	42	0	265	6	8	0--0--0	0--4--21
"	Apr.	Bk.	New Lots and East New York	75,000	New Lots Wells	Catskill	178	17	115	13	7.78	.08	88.4	1.8	309	42	0	265	1	8	0--0--0	0--4--21
"	Apr.	Rich.	North Shore 1 & 3	25,000	W.B.Brighton Wells	Catskill	234	20	86	16	1.30	.09	247.0	1.6	483	47	0	240	20	8	0--0--0	0--4--21
"	Apr.	Rich.	2 & 4	10,000	Boulevard Wells	Catskill	173	20	112	16	1.35	.09	27.4	1.6	238	47	0	240	14	8	0--0--8	0--4--21
"	Apr.	Rich.	3rd	22,000	Clove P S. Wells	Catskill	145	20	102	16	.62	.09	8.7	1.6	148	47	0	240	40	8	10-10-80	0--4--21
"	Apr.	Rich.	3rd.	7,000	Bulls Head Wells	Catskill	133	20	107	16	.60	.09	9.6	1.6	196	47	0	240	9	8	0--0--8	0--4--21
"	Apr.13	Q.	1 & 3	150,000	Long Island Bayside Wells Flushing Wells	Catskill	44 45 71	18	14 29 29	14	1.02 1.46 6.50	.11	30.0 7.5 12.4	1.8	130 103 165	38	25 5 0	206	9 9 10	8	0--1--9 0--2--9 0--0--0	0--6--14
"	May	Bk.	Manhattan & Brighton Beaches	....	Bath Road Well	Catskill	124	17	62	13	1.97	.08	30.9	1.8	260	42	0	265	270	0	0-33-100	0--4--21

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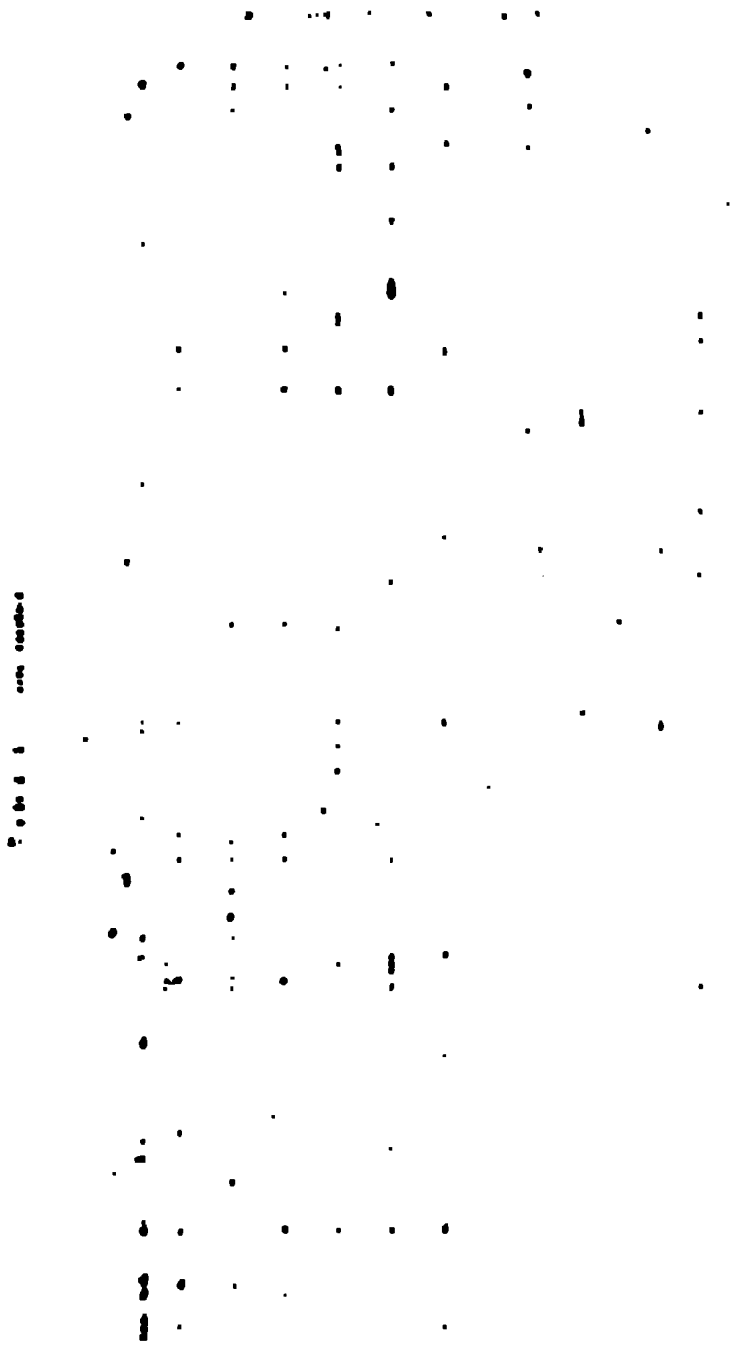

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THE USE OF REINFORCED CONCRETE IN OR NEAR SEA WATER

(Re-print of a report dated May 10, 1921, to the Board of Estimate and Apportionment of The City of New York, by Arthur S. Tuttle, M. M. E. N. Y., Chief Engineer of the Board. The first portion of the report has been omitted as it refers merely to the questions that gave rise to the investigation.)

In the Engineering News-Record article concerning the Santa Monica piers (March 25, 1920) there is contained a report from the consulting engineers who investigated the matter, from which I beg to quote the following: "In consideration of all of the above facts and observations, we believe we are fully justified in concluding that the prime cause of the failure of the pier was the permeable concrete resulting from unskilled or poor workmanship and improper selection and use of materials."

In this article the danger is pointed out of permitting steel reinforcement in structures of this character to be placed too near the surface for an adequate cover, as well as the danger of breaking the skin coating over the concrete by careless handling. It is also noted that "Many, if not all, of these facts have become known as the result of the experience and experiments of the last few years, and were not available to the designers of marine concrete construction a decade ago. In the light of our present information, it is realized that the reinforcement should have been more deeply embedded, but at the time the pier was designed any engineer would have said it was quite sufficiently covered."

In commenting upon the failure of this structure, the Southwest Builder and Contractor (Los Angeles) of November 21, 1919, states that "The value of reinforced concrete construction for sea wharves is not in any way impaired by the failure of the reinforced concrete municipal pleasure pier at Santa Monica. * * * it was the first important structure of its type to be erected on the Pacific Coast. It was regarded by many engineers at that time as an experiment."

In the article which appeared in the Engineering News-Record of January 20, 1921, with respect to the present condition of the piers in the vicinity of Los Angeles, which is referred to by Mr. Ward, the following statement is made relative to their design: "The depth of the steel cannot be determined accurately in every case but all evidence points to a covering generally of less than two inches and in some of the badly cracked piles the steel will be found at a depth less than half that."

William E. Belknap, Consulting Engineer of Los Angeles, under date of March 28, 1921, states that: "Mr. Vincent, the Harbor Engineer here, advises me that they have a concrete pier in the outer harbor, built in 1913, in which the concrete piles show no deterioration. The piles are octagonal, 16 inches and 20 inches diameter, built in forms on the ground, with care taken to get dense, impervious concrete." It would therefore appear that the review contained in this article does not include *all* piers of this type in the Los Angeles section.

I would also draw attention to the opinion recently expressed to me by M. M. O'Shaughnessy, City Engineer of San Francisco, to the effect that he has been "observing concrete pile construction for the last fifteen years on this coast, and if the piles are well-made, dense and seasoned for sixty days before use, there is no reason why they should not be eternal." Mr. O'Shaughnessy has recently completed an important beach protection improvement concerning which he states that it was located along "a very treacherous portion of the coast, exposed to sea action for 3,000 miles of ocean, and predictions of failure were freely made. All critics have been refuted, as this work is now a pronounced success, and I am at present making plans and specifications for another extension of same, so pleased are the city authorities with this type of structure." This project included the construction of an esplanade, the plans for which show that reinforced concrete was used throughout for piles (pedestal and lock-joint) and revetments.

To fully dispose of the questions which have been raised, Engineer Kenneth Allen has been detailed to make a comprehensive investigation as to the use of reinforced concrete at the waterfront in and near this city as well as at Long Beach and Atlantic

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City where boardwalks have long been in use. He has also interviewed a number of engineers experienced in this type of construction and has made an extensive research of the literature covering the subject. The data thus obtained, together with views of engineers from other parts of the country which have been personally communicated, are incorporated in the annexed report made by him, which is believed to fully cover all of the points at issue.

There is also presented a report by William T. Carpenter, Chemist, on the staff of this office, explaining the chemical reactions which endanger the permanency of reinforced concrete structures exposed to sea air or sea water, which I believe to be a valuable contribution to the inquiry. He points out in this report that an additional security against the rusting of the reinforced rods might be obtained by coating them with a cement grout containing 10 per cent. of zinc yellow, but that there is some question as to whether or not the use of this material would be prejudicial to the bond between the rods and the concrete, a determination of which, however, could be reached in a comparatively short time.

From this investigation it would appear that reinforced concrete may be safely used in or near sea water provided that the following conditions are complied with, and as more particularly specified in Mr. Allen's report:

(1) Proper materials, mixing, workmanship, curing and handling must be rigidly insisted upon.

(2) The surface of the concrete must be protected from abrasion.

(3) The steel reinforcement in that portion of the structure above mean low water must be given a cover of at least 3 inches of concrete.

I see no reason why all of these requirements cannot be adequately met in the construction of the boardwalk, and am of the opinion that this type of construction is best adapted to the service required.

I would suggest, however, that the attention of the Borough President be drawn to the desirability of making the experiment proposed by Chemist Carpenter with respect to the effect upon the bond between the steel and the concrete of the coating described by him, designed to prevent the formation of rust, and that in case satisfactory results can be obtained within the time available for the experiment, a requirement for the use of such coating be incorporated in the specifications for the work.

Respectfully, ARTHUR S. TUTTLE, Chief Engineer.

Mr. ARTHUR S. TUTTLE, *Chief Engineer:*

Dear Sir—I beg to submit herewith the results of an investigation into the reliability of concrete and reinforced concrete when exposed to sea water. The report comprises, first, the results of various inspections of structures and a digest of interviews with engineers who have had experience in this matter; secondly, a brief statement of opinions held by various authorities and recorded in the literature of the subject; and, thirdly, such general conclusions as I have been enabled to draw from the information secured, with a few rules recommended for observance in building marine structures of concrete.

I. INTERVIEWS AND INSPECTIONS.

Chas. Gilman, of the Massey Concrete Products Corporation, was interviewed and expressed the opinion that, provided the material and the workmanship are of the best and the steel embedded not less than 2 inches below the surface, and, further, provided the structure is protected from abrasion, there should be no difficulty in securing durability in reinforced concrete exposed to the action of sea water. To produce impermeable work he suggested painting the surface with pitch.

Edward A. Byrne, Chief Engineer, Department of Plant and Structures, did not approve of leaving concrete without protection in sea water and approved of the practice of facing docks with granite. The bad condition of the concrete pier work in the Harway avenue bridge over Coney Island Creek through disintegration was referred to.

Mr. A. W. Stephens, Chief Engineer of the Turner Construction Co., was interviewed. Mr. Stephens saw no cause for apprehension with steel embedded at least 2½ inches in first class concrete, but within the tidal range he would prefer mass

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concrete in place of reinforced concrete piles. As to a protective coating he suggested that Fluosilicate of Magnesium (Lapidolith) might prove to be a good thing.

T. F. Keller, Chief Engineer of the Dock Department, believed that wooden piling would require repairs in 12 years and that 33 per cent. would have to be replaced in 20 years, while the life of a concrete pile might be taken at 60 years.

Henry R. Asserson, Assistant Engineer of the Dock Department, believed that reinforced concrete piles would prove satisfactory if adequate protection from absorption were provided and the steel placed at least 2 inches from the surface. Care should be taken in handling to prevent splits due to bending. Compared with plain or creosoted wood piles with a supporting value of 18 tons, the cost of 15 inches by 15 inches reinforced concrete piles supporting 40 tons each would not greatly differ as to cost.

Mr. Asserson described a pile devised by him which is to be used in the construction of the new ash dump at the foot of Roosevelt street. This consists of a square precast pile with beveled corners with a protective coating above low water level, consisting of three layers of woven fabric and two of felt saturated with tar, a layer of expanded metal and a coating of mortar applied with a cement gun. The cost of this additional protection is estimated at $12 per pile. A patent has been applied for.

Mr. Asserson also suggests the possibility of encasing concrete piles in vitrified clay pipe and filling with concrete.

Edward Anderberg, Senior Assistant Engineer, Barge Canal Terminal, pointed out some reinforced concrete footing blocks at Pier 6, East River, 4 feet by 4 feet by 3 feet high, that were placed about 4 years ago with their base about mean tide level. The ¾-inch bars had a 3-inch cover of concrete. These blocks appeared to be in excellent condition throughout.

A fire wall of concrete laid against a timber pile bent at the same location had deteriorated badly during the same period by a softening of the mortar inside the hard exterior shell. For a depth of an inch or so this was plastic, like putty and sand, and the same condition seemed to exist in the interior of the concrete mass.

Mr. Anderberg mentioned a similar deterioration in six or eight concrete columns in a pier at Greenpoint after three years' use, although the larger proportion were in good condition.

The causes of failure in the foregoing two cases is not clear, but in the case of the fire wall may have been due to contact of water with the green concrete and in the Greenpoint work to careless construction in these particular piles.

He also mentioned a concrete loading platform at some point up the Hudson River, the failure of which was attributed to the large amount of humic acid contained in the pit sand used for mortar.

Mr. F. C. Wight, of the Engineering News-Record, who has made a study of concrete for the past fifteen years, has recently made an extended inspection of reinforced concrete structures along the entire seacoast of the United States, much of it in company with Mr. R. J. Wig. As a result of his observations, Mr. Wight has arrived at the conclusion that reinforced concrete is not to be relied on when in contact with salt water. This is based upon the general failure of such structures, with individual exceptions, both on the Atlantic and Pacific coasts. The cause of failure is often obscure. Mr. Wight thinks it may often be due to salt air finding access to the steel. Deterioration is greatest within the tidal range. Owing to the frequent trouble from corrosion of the reinforcing steel he would prefer plain concrete construction as exemplified in a boardwalk at Deal, N. J. This consists of a central line of piers 8 feet in diameter, corbelled out at the top to sustain a 16-foot walk.

Chas. W. Leavitt, Consulting Engineer, was seen with reference to the boardwalk at Long Beach. This was built in 1905 of 12-inch square piles 27 feet long reinforced with steel bars 1 inch from the surface. The piles were seasoned thirty days before driving. The ends are pointed instead of concave (as in the case of some at Atlantic City) and settled less under a load.

The structure consists of 8-inch by 24-inch beams supported on five 12-inch square piles and is 2.14 miles long. The bents are placed 15 feet 6 inches between centers. The reinforcing steel is normally covered with 1 inch of concrete. About two years ago a very severe storm undermined and demolished a section near the easterly end, where the exposure to the sea is greatest, and further damage was done in that vicinity by a drifting wreck. The damage due to these causes which was confined

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to the section east of the groyne near the Brighton Hotel is irrelevant to the subject under discussion and for this reason and the time available a careful inspection was confined to the section about 4,000 feet long located chiefly between the Brighton and Nassau Hotels.

In this section vertical cracks in the piles nearest the ocean were quite general. Probably 25 per cent. of the piles nearest the ocean in this section show cracks of this nature.

Defects due to disintegration or erosion are less frequent, although instances, especially toward the eastern end, are quite numerous. Over half of the southerly row of piles in the eastern quarter of the section inspected were defective in this way, but on the balance of the work probably not more than 6 or 8 per cent. were defective.

In a few cases transverse cracks occur, and in 6 or 8 per cent. of the southern line of piles more or less of the steel is exposed. The condition of the second row of piles from the ocean side is practically the same, although fewer defects are noted toward the north side.

Although few of them are in a serious condition, the floor beams, particularly on the ocean side of the structure, nearly all contain longitudinal cracks. In perhaps 18 per cent. of these the steel is exposed, usually by cracking off of concrete along the corner or else through the careless placing of the rods which in some cases are left without any cover for a short distance near the end of the beam.

For some reason the floor beams beyond the Brighton Hotel groyne were generally in better condition than those to the west.

Mr. Plummer, Engineer, Brooklyn Navy Yard, referred to some precast blocks 20 inches by 12 inches by several feet in height which rest on wooden piles and support a concrete deck. These were placed at the Navy Yard about five years ago where exposed to the range of the tide and on inspection last summer were found in excellent condition. It was not practicable to make an inspection at the time of my visit.

An interview was had with *W. C. Koehler, Manager, Bayonne Works, Standard Oil Co.,* regarding their concrete pile work. These are precast, 14 inches square at the top and 8 inches at the bottom and are about 45 feet long. He suggested the use of "wax tailings," which melts at 70-75 degrees, as a surface protection where exposed to salt water. Through the courtesy of Mr. Koehler, Mr. C. O. Meyer, Superintendent of the Bayonne Works, and their Engineer, *J. J. Mulhall,* an inspection of the work was made.

The Standard Oil Co. have the following piers at this plant:

Pier.	Size.	Date Constructed.	Description.
Bayonne, No. 5	40 ft. x 580 ft.	1913-1914	Creos. wooden piles, concrete deck.
Bayonne, No. 3	110 ft. x 320 ft.	1919-1920	Concrete piles and deck.
Constable Hook, No. 5	55 ft. x 520 ft.	1917	Concrete piles and deck.
Constable Hook, No. 6	55 ft. x 520 ft.	1916	Creos. wooden piles, concrete deck.

Bayonne Pier No. 3 rests on octagonal piles, 16 inches face to face, reinforced by eight ⅝-inch round bars placed opposite the exterior angles at such a distance from the center that the circumscribing circle is 2 inches from the center of each face. The surface is given a coat of wax tailing and Mexican crude oil, but Mr. Mulhall believes a concrete cover of from 3 inches to 3½ inches would be preferable as a protection from sea water.

The piles were made on the Newark meadows and brought 10 miles to the work by barge.

The mix was 1 : 1½ : 3½. The top is inserted in a concrete block with the base at mean high water level.

The condition of these piles is excellent, but they have as yet been driven less than two years.

Constable Hook Pier No. 5 was constructed in 1917 with piles of the same design. In this work some cracking and spalling has occurred on piles, chiefly between high and low water, and on the under side of the deck slabs, due to the proximity of the

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steel bars to the surface by careless construction. It is the intention to repair the damaged work, amounting to perhaps 10 per cent. of the total, this summer with the cement gun, using a mixture of about 10-15 per cent. of lime and cement.

J. W. Hackney, City Engineer, was interviewed regarding the reinforced concrete work in the *Atlantic City Boardwalk* and the Boardwalk and different amusement piers were inspected.

Portions of the old wooden boardwalk have been replaced from time to time by reinforced concrete piles and girders. That below Tennessee avenue was put in between 1909 and 1911. The most southerly work—below Texas avenue—is of octagonal piles, about 12 inches in diameter. Above Texas avenue there is some work with cylindrical piles of concrete placed around the old steel posts. Between Arkansas and Tennessee avenues the piles are 15 inches square. North of Tennessee avenue the structure is of steel as far as Maryland avenue. From here as far as Atlantic avenue, a distance of some 4,000 feet, the work was done under Mr. Hackney, and consists of a section on the land side of the Boardwalk with round piles between Connecticut and Pacific avenues, built in 1908 and 1910 or 1911, and a section the entire distance with square piles, built in 1914 and 1916.

The round piles are 16 inches in size, with a 2½-inch wrought-iron pipe in the center used in sinking and with four ¾-inch round bars with centers 2 inches from the surface of concrete. They are 28 feet long and the base is stepped out to a diameter of 26 inches. They are made by the Raymond Concrete Pile Co., of 1:2:4 concrete and molded vertically.

The square piles are designed 15 inches face to face, with beveled corners, and are 24 feet, 28 feet and 32 feet long. Each pile has four ¾-inch round bars set so as to give a 2½-inch cover of concrete, and has a sharp point. The mix was 1:1½:3. Piles molded horizontally and cured 30 days.

Mr. Hackney says that near Maine avenue some of these piles 32 feet in length have settled as much as 4 inches, due to vertical vibration set up by the waves.

In a letter to Mr. P. P. Farley, Consulting Engineer, Borough of Brooklyn, dated March 16, 1921, he says:

> "I may state that without having made any actual count, it is my impression that a majority of the piles are, so far as sea water action is concerned, in as good condition as when origmally set. Quite a number of the circular piles have cracked vertically over the longitudinal reinforcing rods and rust stains appear. These cracks appear above as well as within the tide water limits so that it is not apparent that sea water action has been the cause. The square piles show vertical cracks in a very few places. I may state that where deterioration is apparent the action has been only in spots. This might indicate a non-homogeneous mixture. This is clearly evident in some cases. A few piles of both forms are badly corroded—one case to a depth of 5 inches for a foot or so in height, and in several cases to depths of 3 inches. Quite a number had spots eaten out to a depth of one inch.
>
> "The round piles were composed of natural pebbles and the square piles of crushed trap rock.
>
> "The question may however be asked: If you had more boardwalk to build would you use concrete piles My answer would be yes and for two reasons. Where the piles are above high water mark there is practically no deterioration, and this is our condition generally. Secondly, I know of no entirely satisfactory substitute even for the more exposed situations. Creosoted wood in sea water is proof against the teredo for perhaps 10 years or less. The creosote oil leaches out until the portion remaining is without effect. I should of course be guided by the Aberthaw tests and use the rich mixture of 1:1:2, and I would be extremely rigid in the matter of mixing the ingredients."

The general character of the work inspected I consider excellent. There were, of course, occasional defects. For instance, north of Maryland avenue there were noted: At Metropolitan avenue, a slight crack and abrasion; at Rhode Island avenue, a slight crack and abrasion; west of Vermont avenue, disintegration and steel exposed; from Vermont avenue to Oriental avenue, occasional abrasion; west of Oriental avenue, a bad transverse crack in pile.

The piles are less exposed south of Tennessee avenue, but a half dozen defective beams were noted between Indiana and Illinois avenues. These were cracked and in

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mix with sand of 1:3 the compressive strength is 4,300 pounds per square inch, or 2½ times that of ordinary concrete.

A. W. Reynolds, Assistant Master Carpenter, P. R. R., was seen with reference to gunite. Mr. Reynolds states that gunite, as well as ordinary concrete, will disintegrate if exposed to sea water between the levels of high and low water, chiefly through the action of frost. Cases of bad disintegration of plain concrete were cited in Nova Scotia, where material to a depth of some 2½ feet had been removed, and at the crossing of the Mattesquan River in New Jersey, where a drawbridge pier on the New York & Long Branch R. R. had been eaten into about 18 inches. Here it is proposed to protect the repaired structure with interlocking vitrified tile about 2 inches thick applied to the face.

At the Cortlandt street ferry a heavy I-beam coated with gunite in 1913 was subjected to a severe shock, tearing out some of the adjacent concrete, and at the same time breaking and removing some of the gunite coating on the steel. I inspected this and secured a sample of the gunite. This had separated from the steel where broken and a definite separation remained extending for some distance along the bottom of the lower flange. The work elsewhere appeared to be in excellent condition, but it was all above reach of the tide and most of the mass concrete that was within the tidal range was also in excellent condition.

Mr. Reynolds believes gunite to be a superior protection for concrete, but in his opinion any material will disintegrate in time if subjected to frost and tide.

The example inspected shows distinct porosity and brings out the fact that the adhesion to steel may be inferior to the strength of the gunite itself.

H. C. Baird, Consulting Engineer, of New York City, has prepared plans for a bridge across Newark Bay involving considerable concrete work. He believes that with suitable protection to prevent abrasion of the surface concrete is a suitable material to use in marine structures. Mr. Baird considers some form of membranous waterproofing or else gunite superior to an integral waterproofing to prevent absorption.

J. J. Yates, Bridge Engineer, C. R. R. of N. J., who has made a special study of the subject of concrete and reinforced concrete, emphasizes the importance of securing just the right proportion of water in the mix—a matter that is frequently neglected. With two samples made with the same kind and proportions of cement, sand and stone but mixed by two persons, each trying to secure the greatest strength, the result showed one to be more than 50 per cent. stronger than the other simply from a variation in the water used. And for this reason alone the weight per cubic foot has been found to vary from 130 to 168 lbs.

Mr. Yates would use nothing leaner than 1:2:4 for work exposed to salt water, and for the best results would use 1½ bbls. cement per cubic yard concrete. As to water he would use about 20 per cent in excess of that giving the greatest possible strength, which would probably give a 4-inch slump in a slump test. He believes this test should be made regularly during construction and the water so gaged as to secure the best results, as compared with a control test, with the usual variations in the character of aggregate. The concrete should require tamping and not be poured. There is danger in using too much water. By due consideration of all factors and proper field work, Mr. Yates is of the opinion that the product can be foretold with as great certainty as in the manufacture of steel.

With regard to concrete piles, Mr. Yates appeared to favor round piles made in place, but was not emphatic on this point. Protective coatings should be given more study and he thought there might be value in the use of "Minwax", but that a substantial degree of protection was afforded by the natural formation of insoluble carbonates at the surface of the concrete.

II. Experience in the Use of Concrete Exposed to Seawater.

(a) *Plain Concrete.*

Mass concrete has been used for many years in connection with sea walls, piers and other harbor works subject to the action of the tides and the salt water. In New York Harbor there are 8¼ miles of concrete sea wall and in Belgium and Holland such walls have been in use for over 50 years without showing signs of deterioration. Considering the many different brands of cement used in successful work of this

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kind, R. J. Wig and L. R. Ferguson (Engineers, Philadelphia) state (*Eng. News*, Vol. 79, p. 737) that in their opinion "All well-made Portland cements will resist disintegration in sea water *if properly used*." This is with the proviso (*id.* p. 641) that the original surface of the concrete as molded is kept free from abrasion or erosion by mechanical means. This original surface or "skin" of the concrete is normally more dense and more nearly impervious than the interior, due to carbonate of lime formed through the action of the carbonic acid of the air or water on the lime in the cement. The importance of preserving this skin coating from impact or abrasion is evident. Wooden fenders or sheathing or a jacket of non-corrodable metal may be used when damage is liable from logs, vessels or ice, and the use of rounded or beveled forms will reduce damage by fracture. Once the surface is removed erosion and disintegration proceed more rapidly.

Construction seams offer easy entrance to sea water and these should be avoided. Where they occur a film of laitance results and unless carefully removed prevents a firm bond between the two batches of concrete.

Freezing and thawing is responsible for a large part of the damage done to concrete within the tidal range. This, too, is greatly increased by porosity of the concrete.

Chemical disintegration is usually confined to the work lying above low water level and is principally found within the tidal range. In connection with polluted waters, G. W. Fuller, Consulting Engineer, New York City, ascribes this to the formation of sulphuric acid derived from the sulphureted hydrogen in the water when acted upon by the air (Trans. Am. Soc. C. E., Dec., 1917). This would account for the good condition observed in piers in the Passaic River below a depth of one foot mentioned by J. J. Yates (*idem*) while badly disintegrated above, as the river contains a large amount of sulphureted hydrogen.

To secure durable concrete in sea water it should be as dense as possible. The sand should be clean, hard and not too fine and the mix should be rich in a good quality of cement of uniform character, not less than one part cement to six of aggregate (Bul. Am. Ry. Assn., Vol. 22). The batch should not be delivered by a tremie, but should be placed in tight dewatered forms if not precast.

With reference to the sand, Taylor and Thompson say, that if "containing a large proportion of fine grains (it) must never be used in connection with concrete or mortar for sea water construction." (Concrete, Plain and Reinforced, 1909.)

Willis recommends nothing leaner than 1:2:4 (Journal Eng. Club of Balto., vol. 5), while R. E. Bakenhus, Assistant Chief, Bureau of Yards and Docks of the Navy Department, would use nothing leaner than 1:2½:4½. (Trans. Am. Soc. C. E. Dec., 1917.)

> "Nearly all important work in England and France in recent years has been constructed with a very rich mixture, generally about 1:1½:3." (Raymond Baffrey, President, Hennebique Construction Co., Proc. Natl. Assn. Cement Users, 1911).

Examples of the successful use of concrete in sea water are mentioned by H. S. Taft, of Seattle (Proc. Interl. Eng. Cong., 1915, vol. 5). At Dublin a sea wall built in 1872 is still in good condition. At Liverpool 68,400 cubic yards of concrete was removed from a sea wall exposed for 40 years and found in perfect condition. Breakwaters of concrete have been found in good condition in Italy after over 30 years service and in India after 22 years service.

> "In the construction of the famous Key West causeway [the cement (Alsen) used in the structure being imported from Germany], it has been stated that salt water was used in the making of all the concrete. As this structure has shown no signs of disintegration up to date, it would appear that such a use of salt water has no injurious effect on the concrete."

Fresh concrete should be kept intact from sea water as it permeates the mortar, dissolving the lime and leaving an inert deposit of magnesium hydroxide.

Various methods of preventing the absorption of water have been employed, such as a coating of pitch, a covering of metal, a coat of Sylvester compound or water glass, the addition of a small amount of clay or hydrated lime to the mortar, and the various commercial integral waterproofing compounds. Dry Dock No. 4, at the Brooklyn Navy Yard and Morgan's Pier at Glen Cove, Long Island, have been treated in the latter way, but Wig and Ferguson are of the opinion that such compounds are none of them to be recommended.

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M. Voissin, Chief Engineer, Ponts et Chaussees, has devised the following for protection against sea water. For concrete, mix 100 pounds cement with 14 cubic feet of sand and 28 cubic feet of gravel. Cover the surface with a thin coating of cement paste. On this apply two coats of boiling tar, leaving the first to dry before the second is applied.

M. Ravier would replace the tar coatings with two of boiling paraffin, applying the first a month after the cement paste and the second at least two days later. (Eng. News-Rec. March 31, 1921.)

Buel and Hill, in "Reinforced Concrete," recommend in place of the usual gaging water the use of equal parts of a 5 per cent solution of ground alum and a 7 per cent. solution of soap. Mix the alum solution with the cement to one-half the usual amount of water and then add the soap solution. This is virtually the Sylvester process applied throughout the mass of the concrete.

Brysson Cunningham, in his treatise on the Principles and Practice of Dock Engineering (London, 1910), says that "Permeability may be limited to a very slight distance within the surface by the exercise of ordinary care and reasonable precautions." The writer finds "that careful incorporation * * * of the customary ingredients with a final surface wash of pure cement * * * is sufficient to secure a very serviceable, and, so far as he is aware, an inviolable degree of impermeability." "The composition should never be in excess of 5 parts of aggregate to 1 of Portland cement."

As a further suggestion, Mr. Cunningham says that concrete may be made to resist the action of sea water by dissolving an amount of barium chloride equal to 2 or 4 per cent. of the weight of the cement in the gaging water. This forms a perfectly insoluble barium sulphate with the sulphates of the sea water, while the magnesia remains in solution as magnesia chloride. This will not swell or diminish the strength of the concrete. It should be used in the 4 inches to 8 inches next the surface.

R. H. Gaines, Chemist, Board of Water Supply of New York, recommends one of the following ways for securing watertight concrete:

1. Replace the usual mixing water with a dilute (not over 2 per cent.) solution of some suitable electrolyte.
2. Substitute for 5 to 10 per cent. of the cement an equal quantity of dried and finely ground colloidal clay, intimately mixed with the cement.
3. Employ both the electrolyte and the clay as in 1 and 2. (Trans. Am. Soc. C. E., Dec., 1907.)

It is not, however, supposed that the use of an electrolyte in the mix would be advocated in the case of reinforced concrete.

The density of the product depends to a great degree upon the wetness of the mix, but there is a lack of agreement among engineers as to just what this should be. The results of the exhaustive Aberthaw tests at the Charlestown Navy Yard indicate the best results with a wet mix, but Wig and Ferguson believe that these are secured if a light tamping is required.

The use of iron ore (German-American or Hermmoor) cement has been said to reduce the danger of chemical action by sea water and is recommended by Willis and Pagan, Consulting Engineers, Philadelphia (Jour. Eng. Club of Balto., vol. 6) and by Dr. W. Michaelis, Jr., of Berlin, a high authority on cement. (Id., vol. 5.) The Aberthaw tests included two with iron ore cement. Sample No. 16, mixed 1:1:2, remained "good all over" with sharp corners after 11 years immersion, although Sample No. 17, mixed 1:3:6 was pitted to a depth of 1 inch near low water and with corners eaten. Both were mixed wet. Out of 22 samples the only others remaining in "good condition" were Nos. 2 and 3 of normal Portland cement, No. 10 of cement with no iron and No. 14 of cement low in alumina. It is significant that these were all mixed 1:1:2, No. 3 "very wet" and the others "wet." (*Eng. News-Rec.*, Jan. 20, 1921.) The tests, though favorable, fail to show any special superiority in iron ore cement for marine work. Nearly all specimens showed some pitting, generally more when the mix was dry.

The use of sea water in mixing mass concrete does not seem to have had serious results although it appears to be discountenanced by cautious engineers. J. L. Harrison, District Engineer at Iloilo, P. I. (Jour. Eng. Club, Balto., vol. 6) says that sea water results in poor work. E. R. Matthews, in his work on Coast Erosion and Protection, contends that it should never be used for sea walls if fresh water

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is to be had. "The latest elaborate tests which have been made indicate clearly that sea water (used for gaging) *has* a destructive action on Portland cement concrete." This may not be appreciable for 5 or 6 years "but disintegration may be complete in 20 years." On the other hand Wig and Ferguson conclude from their extended inspections involving several hundred pier structures in America and considering the large amount of such work in Canada, South Africa, Tasmania, at Saloniki and in the Firth of Forth, that "sea water or brackish water can be used for mixing unreinforced concrete without deleterious effect." (*Eng. News*, vol. 79.)

As a protection to concrete from the infiltration of water it is agreed that the surface of the work should be as dense as possible and one means of procuring this is to use a specially rich covering of mortar. This must be laid in conjunction with the rest of the work to avoid cleavage between the two mixtures. W. W. Pagon and J. E. Greiner (Consulting Engineers, Baltimore, Md.), recommend a mortar facing 3 inches thick. (*Eng. Rec.*, vol. 73, and Journ. Eng. Club, Balto., vols. v, vi.)

Probably the most effective protection is a coating of gunite from ¾ inch to 1½ inches in thickness, both on account of its strength and hardness when properly made and its firm adhesion to the original concrete as well as on account of its impenetrability. The final product is but 50 per cent. the volume of the dry ingredients and absorbs but 3.7 to 5.5 per cent. its volume of water when 28 days old.

With 2½ parts of aggregate not over ¼ inch in size, per part of cement, the tensile strength is 4,500 pounds per square inch, and with 3 parts aggregate per part of cement, 4,000 pounds per square inch.

To show the degree of imperviousness attainable, a sample 1 inch thick from the Glen Lake dam was subjected to a head of 1,610 feet for 2 hours 20 minutes at the University of California with no moisture showing on the outside. The head was then raised to 3,400 feet with little leakage when the sample broke. (Proc. Am. Soc. C. E., Aug., 1917).

E. E. R. Tratman, Assoc. Ed. *Eng. News-Record*, states that "gunite has the special advantage of high density with small absorption of moisture and close adhesion to steel" (see also Proc. M. E. N. Y., Dec., 1918), and B. C. Collier, Vice-President and General Manager Cement Gun Co., says: "It would seem that all future designs for sea water structures should provide for a coating of gunite applied at the time of original construction, thereby minimizing and removing all possibility of future damage and expense" (*Canad. Eng.*, Oct. 21, 1920).

From the foregoing examples and opinions it is safe to say that the failure of mass concrete exposed to sea water is mainly due to the entrance of sea water to the interior causing chemical disintegration with softening of the mortar, and permitting the formation of crystals of mineral salts, and in cold weather of ice, which, by their enlargement, cause cracks and destruction of the material. The obvious corrective is to secure as dense a concrete with as impervious a coating as practicable.

The following are conclusions reached by several authorities:

D. A. Stevenson, Consulting Engineer, Edinburgh, Scotland—Cement of low tensile strength, plenty of water and suitable proportions in the mix and freedom from clay are desirable. There is no action on concrete along the Scotch coast if made of good ingredients (First Rep. Com. Inst. C. E., on the Deterioration of Structures in Sea Water, 1920).

E. R. Matthews—Injurious action of sea water on concrete is not compatible with numerous examples apparently in good condition (Coast Erosion and Protection, 1913).

Brysson Cunningham—"The writer has seen to the construction of a good deal of concrete, executed without any special precaution, the whole of which during a number of ensuing years has been exposed either to constant immersion or to tidal alternations, without the slightest sign whatever of deterioration. Indeed * * * he is convinced that a harder and more compact material for its purpose would be difficult to find." "The evidence in favor of the permanence of such concrete is ample and conclusive." (Dock Engineering, 1910).

"It is thought possible that concrete may be made that will withstand the action of sea water in warm climates if guarded against abrasion, and by providing special face protection against the action of frost or floating objects between low and high water concrete may also withstand sea water in colder climates" (Bul. Am. Ry. Eng. Ass., No. 233, Jan., 1921).

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"Properly made portland cement concrete totally immersed is not subject to decomposition." (Technologic Paper No. 12, U. S. Bureau of Standards).

A general review of the situation indicates that *with good thorough work and using standard materials and methods there is little cause to apprehend failure of concrete exposed to sea water unless from severe abrasion or impact from vessels or drifting material.*

(b) Reinforced Concrete.

The first use of reinforced concrete in modern work is said to have been in 1854 when an English plasterer bedded hoop iron in the crown of an arch to take the tension and patented the idea; but experience with reinforced concrete exposed to sea water has been chiefly confined to the past 15 years. In a large number of cases it has been attended with unfortunate results.

Raymond Baffrey mentions the first use of reinforced concrete sheet piles at Sables d'Olonne in the Bay of Biscay by M. Hennebique to repair an old sea wall in 1898. These were of 1 : 1½ : 3 concrete, 10 inches by 16 inches by 19 feet in size, with six ⅞-inch rods, and in 1911 were said to be as sound as when driven.

The first reinforced concrete pile in New York Harbor was driven in 1911 at Ellis Island as an experiment. It was 18 inches square.

At Nantes a dock built in 1902 with concrete piles was in good condition in 1912.* This and many other examples in foreign countries are given by H. S. Taft in Trans. Am. Soc. C. E., vol. 78, 1915, prominent among which are a coal barge jetty at Southampton in 29 feet of water, where the load per pile is 17 tons; several similar docks of the L. & S. W. Ry. at London which "show no signs of wear or deterioration * * * (and) have cost nothing to date for maintenance"; the Purfleet coaling jetty built in 1904, and pile work at Dundee unaffected by a 12 foot tidal range or frost. In discussing Mr. Taft's paper, C. S. Meik, Engineer in charge of the Purfleet work, refers to bars from a pile submerged for 8 years as being as free from rust as when put in; W. Goldsmith, General Manager, Riverdale Constr. Co. of New York City, refers to piles in the Philippines, mixed 1 : 2 : 4, without deterioration in 5 years, and W. J. Douglas, Consulting Engineer, New York City, to 16-inch, 18-inch and 20-inch piles with ¾-inch to 1¼-inch round bars centered 2 inches from the surface as in good condition when examined.

The excellent review of the subject contained in the first report of the Committee of the Inst. C. E. on "The Deterioration of Structures in Sea Water," cites many examples along the British coast where reinforced concrete has been extensively employed during the past fifteen years.

Wentworth-Shields, Dock Engineer of the London and Southwestern Ry. Co., is quoted regarding rusting at Southampton: "This rusting action takes place only above high water level; below high water neap tides, when the piles and bracing are kept constantly wetted, they are still quite unaffected, but above that level the piles, bracing and underside of decking have suffered considerably." The pier here was subjected to very heavy traffic.

Mr. Meik says, as to the Purfleet pier, that cracks in the surface of piles and bracing admit moisture, causing trouble about high water level of spring tides, below which the work is usually all right.

As to London, C. R. S. Kirkpatrick, Chief Engineer, Port of London Authorities, reports: "No serious deterioration was found below high water level. * * * In no case are the defects in reinforced concrete work attributed to the concrete itself."

Mr. E. A. Cullen, Engineer of Harbours and Rivers, reports, as to Brisbane, the prevalence of cracks near the junction of piles and beams, causing rust. Rust was also found where stirrups, due to displacement, were left with but ¼-inch cover. It was also found on the underside of decks and deck beams, but *not below neap high water.* He thinks protection from the air more necessary than from the water. Iron doesn't rust while immersed, but while drying the action is rapid. Below high water it doesn't have time to dry out, while above it is alternately wet and dry. According to Mr. Kirkpatrick: "In no case are the defects in reinforced concrete work attributed to the concrete itself."

H. S. Taft (Proc. Inter'l. Eng. Cong. 1915, vol. 5) mentions deterioration at Liverpool of the underside of a concrete deck due to inadequate cover of poor concrete over steel and of piles at Southampton due to electrolysis.

* The water here is probably fresh.

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Generally speaking, experience along the British coast has been favorable, exceptions being usually confined to portions above neap high water level.

In America there have been many failures, as pointed out by Wig and Ferguson (*Eng. News-Record,* vol. 79) and these are mainly through cracking above the high water line. Of some 2,500 piles along the Atlantic coast made with good concrete, nearly every one was found cracked or spalled after ten years' use. Also at Long Beach, Cal., reinforced piles made in 1911 and left above tide on the shore, are nearly every one of them cracked when mixed wet, but not when mixed dry. Deterioration is more rapid in warm temperature. As most American structures are built with fresh water, failure is not due to salt in the mix and they do not find electrolysis a common cause of trouble.

A striking instance of failure due to fresh water is given by Prof. F. E. Turneaure (*Eng. News-Rec.,* Jan. 3, 1918) in the case of reinforced concrete water tanks covered with 8-inch floor slabs in the hydraulic laboratory of the University of Wisconsin. The work was constructed in 1906 of 1:2:4 concrete, which proved to be of excellent character. The cover over the steel in the slabs was 1½ inches and in the tanks it was less than this. Within 10 or 12 years spalling to a depth of 1½ to 2 inches occurred over the rods in the tank walls, which were alternately wet and dry. Where constantly submerged the steel remained practically without rust, but in the bottom of the floor slabs, where exposed to damp air without circulation, there was also more or less rusting and spalling.

Reinforced piles in Pier No. 2 at Halifax composed of 1:1½:3 concrete were found intact on inspection, but A. F. Dyer believes a 4-inch sheathing of creosoted plank from low water to 18 inches above high water spring tides desirable as protection against frost and ice (*Eng. and Cont.,* Nov. 20, 1918) C. E. W. Dodwell, M. Inst. C. E. of Halifax, reports damage to a depth of 15 inches in 7 years at that place, but attributed it to porosity of concrete rather than rusting (1st Rep. Com. Inst. C. E., 1920). At Boston, too, failures have been due to porous concrete, due to the action of the tides on green concrete.

W. Goldsmith mentions 1:2:4 piles at Philadelphia showing no deterioration in sea water in 5 years (Trans. Am. Soc. C. E., vol. 78), but it should be remarked that this sea water was "fresh."

The influence of salt was well illustrated by the reinforced concrete structures in North Carolina, supporting 25 beacon lights located in a stretch of 25 miles of river from the ocean to a point above the limit of salt water. Wig and Ferguson note a progressive increase in deterioration by rusting after four or five years' use from the upstream beacon down, this one showing no corrosion.

These investigators found very bad conditions along the Pacific Coast and further details are given in *Eng. News-Record,* January 20, 1921. The piles ranged from 10 inches to 24 inches in diameter and their unbraced height is "exceptionally great"—in some cases 50 feet. They had been in use from one to seven years. Little disintegration was noted at Los Angeles, possibly due to a coating of oil. Generally conditions are "deplorable," with vertical cracks over reinforcing bars in nearly every pile within the tidal range. The deterioration is practically all due to this cause, the face of the concrete remaining good. The depth of steel could not be determined in all cases but "all evidence points to a covering generally of less than 2 inches and in some of the badly cracked piles the steel will be found at a depth less than half that." But there is also "evidence that the penetration of the corrosive salts can go much deeper than 2 inches at times."

Corrosion seems to be limited to the zone above low water level. Anchoring steel in a block submerged from 1848 to 1907 was found unaffected and iron rods from the Eddystone Lighthouse, submerged from 1857 to 1881, were found without rust (Proc. Nat. Assn. Cem. Users, vol. 7, 1911).

The late Edwin Thatcher, consulting engineer, New York, mentions ¼-inch and 1/16-inch rods or wire used in constructing a concrete-steel water main 1.6 inches thick at Grenoble, France, which were found absolutely free from rust after 15 years' service. (Trans. Am. Soc. C. E., vol. LIV-E).

The failure of the Santa Monica pier, which was examined in 1919 after ten years' use, by a board of engineers, was pronounced in their report to be primarily due to permeable concrete due to poor materials and work (*Southwest Builder & Contractor,* Nov. 21, 1919).

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W. E. Belknap, consulting engineer, Los Angeles, Cal., mentions a pier in Los Angeles harbor built in 1913 of 16-inch and 18-inch precast octagonal piles which, according to Mr. Vincent, the harbor engineer, shows no detioration, although a neighboring private pier built somewhat earlier shows marked deterioration. The concrete in the former pier is dense (Letter to A. S. Tuttle, Mar. 28, 1921).

M. M. O'Shaughnessy, City Engineer, San Francisco, writes of inferior construction eight or nine years ago and refers to the failure of poorly designed structures in Southern California, but mentions marked success with precast piles used on the Esplanade at San Francisco at a very exposed point in the coast, for which he is planning an extension. The piles are 19 inches square, of 1:1½:3 concrete and with 8 ⅞-inch bars 2 inches from the surface (Letter to A. S. Tuttle, Mar. 28, 1921). H. E. Squire, Assistant Harbor Engineer, San Francisco, mentions steel bedded 1 inch in a test pile in the harbor as being intact after 11 years (*Eng. News-Rec.*, Mar. 21, 1918.)

T. S. Williams, State Harbor Engineer, San Francisco, says, in speaking of concrete wharf supports: "Our practice is never to use concrete unless reinforced by steel rods." (*Canadian Eng.*, vol. 31, p. 347.)

On the other hand, M. W. Brown, Consulting Engineer, New York City, who was in Spain during the late war, says that at that time the Spanish Government was abandoning the use of reinforced concrete in sea water on account of unfortunate experience at Barcelona and elsewhere.

Experiments are being carried out to throw more light on this matter at Brisbane, Queensland.

While there is a conflict of opinion regarding the best policy, engineers are taking fuller precautions to secure reliable results.

At Los Angeles piles 18 inches to 20 inches in size and 42 feet to 60 feet long, are being constructed of 1:1½:2½ gunite 4 inches to 4½ inches thick, about an 11-inch core of tar paper, transported and placed all in a vertical position to prevent cracking by handling. They are cured for at least 30 days in a vertical rack before driving. (*Eng. News-Rec.*, Mar. 10, 1921.) T. S. Williams would always allow 30 to 60 days for setting.

The proper cover to give the steel is a matter of great importance. Wig and Ferguson find bad erosion and spalling at a depth of 2½ inches and find that even 3-inch cover will not insure marine structures against corrosion. Kirkpatrick places the minimum depth at 1½ inches; W. H. Hamer, engineer to the Harbor Board, Aukland, New Zealand, at 1¾ inches to 2 inches; Wentworth-Shields at 2½ inches; the Committee of the American Railway Engineering Association at 3 inches, and from any two adjacent faces, 4 inches.

As a protection against electrolysis the American Railway Engineering Association recommends the placing of a "waterproof plastic layer of material with petroleum asphalt base, or same established waterproofing material free from electrolytes," on the exposed surfaces of concrete structures in order to prevent penetration of salt air or moisture. (*Eng. News-Rec.*, Mar. 31, 1921.)

In Taylor & Thompson's opinion: "Concrete, if mixed wet, protects steel reinforcement from rusting." (Concrete, Plain and Reinforced, 1916.)

Wig and Ferguson suggest the use of small-sized rods deflected toward the centre from a little below low water up, the entire omission of steel above low water or the application of a galvanized steel casing above water level and great care in the amount of water used in mixing. The mix should be somewhat wetter than for plain concrete. Waterproofing compounds are not recommended.

F. J. Litter, Chief Engineer, Snare & Triest Co., New York, believes reliable work can be obtained by selecting and testing good materials, mixing in the ratio of 1:2:4 for 1¼ minutes in a power-driven mixer with just enough water to make a "free flowing velvety mass," using tight forms, puddling and wetting down periodically for a week. Steel should not come within 1½ inches of the surface. In the case of piles, they should be cured for four weeks and so supported that they are not unduly subjected to bending. In hard material they should be jetted down, but in soft material they may be hammered with the use of a cushion block (*Eng. News-Rec.*, April 14, 1921).

The following opinions of different authorities are an aid in drawing personal conclusions on the subject:

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E. G. Walker, of Hull, England—"There is no question that concrete and reinforced concrete can be used successfully for marine works" (Trans. Am. Soc. C. E., vol. 78).

C. S. Meik—"Deterioration by sea water of steel in good reinforced concrete is a negligible quantity" (*idem*).

H. S. Taft—"The writer was amazed to learn of the large number of reinforced concrete docks that have been built in foreign countries and the great success that has apparently been obtained in them. Current English technical publications indicate that there is hardly a port of any prominence along the coast where reinforced concrete construction is not now being carried on extensively * * * due to the great economy of such structures over their old wooden predecessors in the way of maintenance expenses" (*idem*).

F. E. Wentworth-Shields—"If great care is exercised in making and placing concrete, an impermeable material will be obtained which can withstand the action of salt water." He is inclined to feel that there is nothing special to be feared respecting the life of reinforced concrete when used in marine work. * * * "A ten-year-old reinforced concrete structure standing in sea water at Southampton is in perfect condition at the present date; and * * * during the whole experience at Southampton sea water does not seem to have produced any chemical or other deleterious action on the concrete" (1st Rep. Com. on Deterioration of Structures in Sea Water, Inst. C. E., 1920).

Wig and Ferguson—"Steel embedded in first-class concrete to a depth of 1 or 2 inches in accordance with existing theory and practice is not perfectly protected against corrosion by sea water. Reinforced concrete of excellent quality, designed according to recommendations of engineering societies and present practice, is subject to relatively rapid deterioration in most localities, but they also believe that both mass and reinforced concrete can be used in sea water with durable results" (*Eng. News-Rec.*, vol. 79).

U. S. Bureau of Standards—"Metal reinforcement is not subject to corrosion if bedded more than 2 inches. With less than 1 inch it is probable" (Technologic Paper No. 12, U. S. Bureau of Standards).

T. S. Williams—"Where bottom conditions permit, we exercise a preference in favor of concrete over wood, however treated or protected; and when it comes to concrete we prefer the driven pile to the built-up cylinder type" (*Canad. Eng.*, Nov. 2, 1916).

Bertram Blount, Mem. Inst. C. E.—"It seems fairly certain that little fear need be felt of steel reinforcement rusting when well embedded in good non-pervious concrete of adequate thickness, even when the structure is exposed to sea water or other saline solutions, but the case is altered when the concrete is exposed to electrolysis. The advantage of an alkaline medium may disappear, and the steel reinforcement serving as an electrode may be attacked by all the negative ions of the electrolyte. Corrosion will be rapid, and the stresses exerted by iron rusting are known to be large" (*Concrete Age,* Apr., 1916, p. 28).

Raymond Baffrey—"With molecules of mixture in perfect contact, as is seen in such concrete structures subject to sea water for over fifteen years, the action is absolutely nil" (Pro. Natl. Assn. of Cement Users, vol. 7, 1911).

Committee Am. Railway Eng. Assoc.—"Steel embedded in dense concrete will not corrode when located either above or below fresh or sea water level" (*Jour. Eng. Club of Balto.,* Mar., 1916).

Committee of Inst. C. E. on The Deterioration of Structures in Sea Water—"Where possible, mass concrete should be adopted for such parts of concrete structures as will come in contact with sea water, between high and low water, and even for the parts above the high water line steel should be so placed that there is at least 3 inches dense concrete between the surface of the concrete and the face of the steel to prevent moisture from the salt air penetrating to the metal" (First Rep., 1920).

Joint Committee on Concrete and Reinforced Concrete—"Steel sufficiently embedded in good concrete is well protected against corrosion, no matter whether located above

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or below water level. It is recommended that such protection be not less than one inch in thickness" (Final Report, Trans. Am. Soc. C. E., 1917).

Robert A. Cummings—"In the case of reinforced concrete piles, a rich cement mixture with a maximum density, with ample protection to the steel reinforcement, is necessary. When you meet this condition you will have a permanent structure above or below ground line. In the matter of creosoted piling I have observed a tendency for the leaching out of the preservative, especially at New Orleans, where piles and poles were found to develop rotting at the *top*, while the part remaining in the ground is in excellent condition" (R. A. Cummings to A. S. Tuttle, March 18, 1921).

M. M. O'Shaughnessy has observed concrete pile construction for the past 15 years and is of the opinion that, if "well made, dense and seasoned for 60 days before use, there is no reason why they should not be eternal. * * * The failure of poorly designed structures in Southern California furnishes no warrant for the condemnation of proper concrete pile construction. * * * The additional precaution, however, of giving them a coating will be an insurance for their protection which is well worth making. In San Francisco we have not found this treatment necessary" (letter M. M. O'Shaughnessy to A. S. Tuttle, April 14, 1921).

W. E. Belknap—"My experience with concrete in sea water makes me feel it is all a question of making a *dense impervious surface* (3 inches to 4 inches thick at least to stand attrition) to prevent crystallization, freezing, etc., in the concrete structure. Also close, vigilant inspection. I would not base conclusions against the use of concrete on the experience to date out here because I should be inclined to feel that the methods were not perhaps as good as they might have been" (letter W. E. Belknap to A. S. Tuttle, Mar. 28, 1921).

F. E. Turneaure (with reference to fresh water conditions). "The least that can be said is that great care must be taken to cover all the rods to a considerable depth with good, dense concrete." Where air circulates freely no trouble need be apprehended (*Eng. News Rec.*, Jan. 3, 1918).

Turneaure and Mauser—"When well placed the concrete affords complete protection against corrosion" (Principles of Reinforced Concrete, 1909).

L. V. Morris, Chief Engineer Long Island R. R. Co.—"The effect of marine borers must be considered should timber piles be used. There are some creosoted piles 40 years old in our Jamaica Bay trestle, but they are not all sound; some have rotted inside of the creosoted shell, while others, when checked or damaged, so as to expose the untreated interior, have been attacked by teredo.

"If we were renewing any of our bridges in salt water with a modern structure, that is concrete deck, unquestionably we would use reinforced concrete piles, as I know of no reason if they are properly constructed why they should not last much longer than treated timber. We have used concrete piles exposed to the weather, but not in connection with salt water and in no case have we found any deterioration, except possibly an occasional pile due entirely to faulty construction.

"I would not hesitate, therefore, to recommend concrete piles if of good design and of the highest grade of construction" (letter L. V. Morris to A. S. Tuttle, March 24, 1921).

A consideration of the above experience and opinions regarding the use of reinforced concrete exposed to sea water leads one to believe *that the unfortunate results observed in many structures has been due to causes which are now recognized as preventable and that it is largely a question of the ability to secure rigid control of construction methods that should determine whether this material should be adopted or rejected in any given work.*

III. Conclusions.

While there is a decided difference of opinion as to the reliability of concrete—and especially reinforced concrete—exposed to sea water, it seems to be acknowledged that the concrete must be of the best and that the steel should be practically inaccessible to the infiltration of sea water. Otherwise we have:

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In the case of plain concrete, disintegration due to chemical reactions between the water and the ingredients of the concrete, accelerated by the presence of salts in the water and possibly conveyed through the air by spray and mist. It is also accelerated by the expansive force of minute ice crystals which form in the pores of the concrete during low tide or when wet by spray in cold weather.

Disintegration of concrete may be prevented by the use of proper materials and workmanship and by care in preserving the original surface of the material intact. To secure this the work, if, subject to impact or erosion, should be protected by fender piles, sheathing or a casing of galvanized iron.

In the case of reinforced concrete, failure probably also occurs by the absorption of salt water, but in this case two further actions may take place. If there are stray electric currents from transmission lines, etc., electrolysis may cause rapid destruction of the steel. This, however, is not common in marine structures. But when water reaches the steel and then evaporates with the falling tide corrosion is started. This may be insignficant in extent for a long time. The first indication is usually a rust spot on the surface. As it proceeds the rust occupies more space. Wig and Ferguson say that it occupies about twice its original volume and Meik (1st Rep. Com. Inst. C. E. on Deterioration of Struct. in Sea Water), gives the expansive force thus developed as 4,700 pounds per square inch. There is nothing left for the concrete but to crack more and more as corrosion proceeds permitting the rusting also to increase in extent until the concrete cover is ultimately destroyed.

Whether the admission of moist air alone to the steel is a serious cause of failure is a matter of opinion, but the action is probably greatest where the steel is alternately wet and dried. Although we speak of the "salt air" it is questionable whether salt is ever really conveyed in the air except as spray.

Aside from theoretical considerations the fact remains that there have been numerous failures of concrete, both plain and reinforced, in sea water, but particularly in reinforced work. Although the preponderance of opinion quoted expresses confidence in these materials the exhaustive inspections by Wight, Wig and Ferguson leave us with no doubt as to the general failure to secure permanent construction with these materials in America. I believe that if all the facts were known these failures could always be traced either to improper design, improper material or improper workmanship. To secure dependable work practically 100 per cent. excellence is required in all these elements and if, for industrial reasons or incompetency on the part of those responsible for the work this cannot be assured, there will always be a certain risk in using these materials.

There is sufficient testimony that it is practicable to secure reliable work under favorable conditions, and in comparing results with timber or steel structures it is to be remembered that these, too, are subject to deterioration or failure, depending on their design, material and erection.

To ensure reliable results with reinforced concrete in sea water the following rules are suggested:

Rules for Securing Durable Work.

1. Use some well-known Portland cement of good character, with clean, hard, graded sand and gravel not over ¾ inch or 1 inch in size.
2. Mix 1 part cement to not over 4½ parts aggregate with just enough fresh water so that it will settle in place and envelop the reinforcing rods with light tamping.
3. Complete the placing of concrete in each pile or unit in one operation so that there will be no construction seams.
4. To secure a dense smooth skin some mineral oil should be applied to the forms. If practicable a richer mortar than the average and about 3 inches thick may be applied next the forms, keeping the larger pieces of aggregate away from the surface, but if this is done the mortar face should be placed at the same time as the rest of the concrete.
5. Reinforcing material above the level of low water should be placed at least 3 inches from the face of the concrete. Below low water level a protection of 2-inch cover will suffice.
6. Allow the work to become thoroughly hard before permitting exposure to sea water. In the case of precast members this should be not less than 30 days.

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that corrosion is most marked above the water line in no wise invalidates the theory. In the first place interstitial crystallization cannot occur below the waterline because it is the result of evaporation. Atmospheric oxygen cannot gain access to the steel, and the oxygen concentration in sea water is only from 1/20 to 1/30 that of atmospheric oxygen. Rusting, like all other chemical reactions, takes place at a rate proportional to the concentration of the reagent, and the dissolved oxygen of the sea water when consumed in the rusting process, must be replaced by the somewhat slow process of diffusion.

Any corrosion below the waterline must, then, proceed with relative slowness, as compared with that above the waterline, where, as outlined above, tiny cracks from crystallization admit moisture and atmospheric oxygen to the steel in the presence of electrolytes.

Passive State and Rust Inhibitors. When iron is immersed in certain oxidizing reagents, notably salts of chromic acid, it acquires an ill-understood quality of "passivity" which renders it immune from corrosion. Following removal from contact with the chromate, the passivity disappears after a time, so that to secure this condition permanently, the iron must remain in contact with the reagent.

Cushman (Corrosion and Preservation of Iron and Steel, p. 163) describes experiments which demonstrate that samples of iron kept in suspensions of insoluble chromates are markedly inhibited from rusting.

Conclusions. Reflection on the facts set forth in the above discussion does not give rise to great optimism for the stability of either plain or reinforced concrete in sea water unless the work from design to completion is conducted with extraordinary care.

The water must be prevented from entering the interior. The reasonable doubt introduced by Squire's experiments into the protective value of the carbonate skin makes it the part of prudence to insist upon rich, dense, material.

Increasing the depth of cover over the reinforcement to 3 inches would give reasonable security.

As additional precaution beyond that afforded by highly dense concrete and deeply buried rods, it is suggested that the rods might be painted with a grout of 90 per cent. Portland cement and 10 per cent. zinc yellow (a chromate paint pigment which showed the greatest inhibiting power in Cushman's experiments).

Before including this in building specifications, however, experiments should be made to determine whether or not the presence of the pigment would injure the bond between the steel and the surrounding concrete. Satisfactory information on this point could be obtained in a few weeks. Respectfully submitted,

WILLIAM T. CARPENTER, Chemist.

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Daniel L. Turner, M.M.E.N.Y., Consulting Engineer, Transit Commission, addressed the Society on the general subject of "Moving Platforms" and was followed by H. S. Putnam, Consulting Electrical Engineer, who discussed this subject more particularly from the point of view of the electric carrier system, using moving pictures to illustrate his remarks. An interesting discussion followed.

The meeting then adjourned and refreshments were served.

MUNICIPAL ENGINEERS BUDGET, 1922

Budget and Account Number		Item	Allowed for 1922
Secretary	1	Postage	$50.00
	2	Salary of Secretary	500.00
	2–A	Salary of stenographer	50.00
	2–B	Salary of lantern operator	40.00
	3	Printing, Secretary	250.00
	4	Medals and prizes	42.00
	5	Certificates and badges	20.00
	6	Treasurer's bond	10.00
	7	Telephone listing	8.00
	8	Miscellaneous	35.00
		Total	$1,000.00
Publication Committee	9–A	Stationery and printing	5.00
	9–B	Postage, including JOURNAL	40.00
	9–C	Drawings	5.00
	9–D	Editing	200.00
	9–E	Typewriting	10.00
	9–F	Commission on advertisements	.....
	9–G	Printing JOURNAL	1,000.00
	9–H	Plates for JOURNAL	60.00
		Total	$1,320.00
House Committee	10	Rent, Room 601	700.00
	10–A	Lecture Hall	400.00
	10–B	Miscellaneous	20.00
	11	Collations, etc.	500.00
	12	Entertainments	110.00
		Total	$1,730.00
President	8–A	Typewriting, etc.	20.00
Treasurer	8–B	Typewriting, etc.	20.00
Finance Committee	8–C	Typewriting, etc.	10.00
Inspection Committee	13	Inspections and printing	20.00
		Total	$70.00
		Grand Total	$4,120.00

BOARD OF DIRECTORS, December 28, 1921.—President Philip P. Farley presided. There were also present Messrs. Powers, Powell, Endemann, Schaeffer, Brush, Tidd, Bell, Hunter, Riedel, Thomas, Ferris, Griffin, Raisman, Dobbin, Borst, Koch and Moon.

The minutes of the meeting of November 22 were read and approved.

The Finance Committee's report, submitting vouchers aggregating $353.63, was accepted and the bills ordered paid.

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MEETING OF THE SOCIETY, December 28, 1921.—President Philip P. Farley presided; 175 members and guests were present.

The minutes of the meeting of November 22 were read and approved.

The report of the Nominating Committee was presented, making the following nominations for Officers of the Society for the coming year:

For President	CHARLES U. POWELL
For First Vice-President	CLARENCE F. BELL
For Second Vice-President	PERCY C. BARNEY
For Treasurer	HERMAN K. ENDEMANN
For Secretary	VERNON S. MOON
For Directors for a Term of Three Years	WILLIAM H. CHERRY HARRY W. LEVY HARRY C. LIBBY JOHN P. LONERGAN ARTHUR W. TIDD

The paper of the evening entitled "The Narrows Tunnel and its Relation to the Port of New York Problem", was then read by the authors, Arthur S. Tuttle, M.M.E.N.Y., Chief Engineer, Board of Estimate and Apportionment, and Colonel William J. Wilgus, Consulting Engineer, Major John F. Sullivan, M.M.E.N.Y., Consulting Engineer, and Jesse B. Snow, Tunnel Engineer, members of the staff of the Chief Engineer of that Board. The paper was discussed at length, the meeting adjourning at 11:45 P. M.

NOTES AND PERSONALS

GEORGE G. HONNESS, Department Engineer of the Reservoir department of the Board of Water Supply, recently delivered a lecture on the Catskill Mountain Water Supply System before the Men's Club of the First Presbyterian Church of Stamford, N. Y. Mr. Honness illustrated his lecture with numerous lantern slides and particularly featured the work upon the new Schoharie development, which has been under his supervision since its inception.

CHARLES M. CLARK was appointed Department Engineer of the Board of Water Supply on December 13 and has taken charge of the construction of the new siphon pipes of the Catskill aqueduct; for several years past Mr. Clark was division engineer on the construction of the Shandaken tunnel at Allaben, N. Y., and for nearly thirty years has been continuously employed on the additions to the New York water-supply, having been on the engineering staff of the Aqueduct Commissioners prior to his service with the Board of Water Supply.

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C. B. J. Snyder, Supt. of School Buildings, has actively commenced operations under the program for school buildings to cost $75,000,000 recently adopted by the Board of Education. The Tilden Building, a large new reinforced concrete building at Conduit Street and Flatbush Avenue Extension, has been purchased by the City near the Brooklyn end of the Manhattan bridge with ample space to house the several divisions of Mr. Snyder's force, which must be materially enlarged to cope with a situation that calls for a remedy with the least possible delay. Some of the divisions have already moved into the new quarters and it is planned to proceed with the program with the greatest possible rapidity.

George A. Tilden, who accompanied the party of Brooklynites last summer on an overland trip to Boise, Idaho, to take up a section of government irrigated land, has recently returned with his family to his home.

Commodore V. V. Powers, who has served the Society in a very efficient manner as Second Vice-President during 1920, and as First Vice-President during 1921, declined the urgent invitation of the Nominating Committee to place his name in nomination for President for the year 1922.

Ray C. Ewry, of Olympic Championship fame, and Mechanical Engineer of the Board of Water Supply, is taking an active part in the organization of the Mayor's Committee on Municipal Athletics. It appears that there is an amazing amount of athletic talent among City employees, particularly in the ranks of the engineering staffs.

The next issue of THE MUNICIPAL ENGINEERS JOURNAL will contain the discussion of Paper 130 on "The Design and Construction of an Important System of Sewers in Brooklyn Known as the Ralph Avenue Sewer System", which was read by the author, JOHN C. RIEDEL, M.M.E.N.Y., at the October 26, 1921, meeting of the Society.

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ADDRESS OF PRESIDENT PHILIP P. FARLEY—ANNUAL MEETING JANUARY 25, 1922

One of the By-Laws of the Society provides that the retiring President shall make an address and it is quite specific as to its character. It states that the President shall review the progress of municipal engineering work and the activities of the Society during the year. It also says the engineering accomplishments are to be described, seems to me a good rule, if we are to judge the matter by what has been done in the past. Some of the former presidents apparently considered that great detail was required while others seemed to think that quite sufficient to refer only to the more important engineering work. This, in my opinion, seems to be the best course and is that which probably is expected. For instance, to enumerate all the engineering municipal engineering work in New York it is better to consult the reports of the several City departments.

Because this is my view of the requirements, I shall touch briefly on a few only of the many improvements upon which the engineers of the City have been engaged during the past year. If I appear to [illegible] the value of work done or if I fail to refer to anything important, I shall have to ask you to charge [illegible] lack of knowledge and to the hurry with which this address had to be prepared.

In my opinion, the year 1921 will be remembered chiefly for the marked revival of interest in the Port of New York. It saw, for example, the enactment of two laws at least in this State, which cannot but result in greatly improving the manner of doing business in the port. One of these provided for the establishment of the Port Authority, a body composed of three members from New York and three from the State of New Jersey, appointed for the purpose of preparing "a plan for the comprehensive development of the port". The other law known as Chapter 700 of the Laws of 1921, directed the City to construct a tunnel from Richmond to Brooklyn for the joint use of freight and passenger traffic.

That these laws resulted in the creation of organizations which to an extent may be antagonistic does not affect the main question as to their importance. This, naturally, is not the time or the place to engage in controversy; and what my views may be in the matter is not now of particular importance. The vital thing is, that by

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county. The cost of the physical improvement has been estimated at $2,800,000 of which the State, under the provisions of the act, is to pay 65 per cent. and the balance is to be paid by the Boroughs of Brooklyn and Queens and by Nassau county. This is the first time that a State appropriation has been made available for the construction of a highway within the limits of the City of New York. The boulevard will run through Massapequa, Seaford, Wantagh, Bellmore, Merrick, Freeport, Baldwin, Rockville Centre, Lynbrook and Valley Stream.

Another very large undertaking for which plans were prepared by the engineers in Queens borough is the construction of the Jamaica Bay boulevard, which will connect Queens and the remainder of the City with the Rockaway peninsula by a crossing over the waters of Jamaica bay. It will be located just west of the Long Island Railroad trestle and will have its southerly terminal at its intersection with the existing boulevard which joins Belle Harbor and Far Rockaway. The new boulevard will also connect various islands in Jamaica bay with the mainland and this will induce a more intensive development of these islands. The length of the boulevard between its northerly terminus at Sheridan avenue and its southerly terminus on Rockaway beach is 5½ miles. The width is 100 feet. The distance from Manhattan borough to the Rockaways, which by the present route is 25 miles, will be reduced to 15 miles upon the completion of the Jamaica Bay boulevard. Work under the contract was begun on October 29 last.

After agitation extending over a period of twenty years, Coney Island, New York City's most famous seaside resort, is to have a boardwalk. It will be built in connection with the Coney Island beach improvement. The contract has been awarded and work is under way. The cost will be slightly under $2,000,000 and there are features about the plan, which if not of a high engineering order, are sufficiently novel and spectacular to render them notable. Chief among these are the protection of the beach by means of timber groynes and stone jetties and the moving of the high-water mark seaward a distance of about 200 feet through the agency of hydraulic dredges operating in the open sea 1,500 feet off-shore and the depositing by these dredges of 1,750,000 cubic yards of sand on an unenclosed shore. The boardwalk itself will be 80 feet wide, a little less than two miles long, is to extend from Ocean parkway to Sea Gate and will be constructed of reinforced-concrete piles supporting reinforced-concrete girders, timber floor beams and a wood deck.

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The activities of the Department of Plant and Structures seem to multiply and the year 1921 gives ample evidence of the variety of its operations. One very interesting improvement now under way is the substitution of a vehicular roadway on the easterly upper deck of the Manhattan bridge for the two surface-car tracks which were in use until 1919 when the operating company abandoned the route. The conversion of this roadway area from surface-car to vehicular use was demanded by the great increase in the latter class of traffic.

Work continued on the Eastchester Creek bridge and at the close of the year was 80 per cent. completed. The new structure will be a two-leaf trunnion bridge with a roadway 53 feet wide and two sidewalks each 8 feet 6 inches.

The department also constructed during the year five housing stations to properly care for the greatly enlarged motor and snow-removal equipment of the Department of Street Cleaning.

A new ferry between Classon Point in The Bronx and College Point, Queens, and another between Grand street, Manhattan, and Broadway, Brooklyn, were put into service during the year. These, with the Greenpoint ferry taken over by the Department of Plant and Structures, are all being operated by the municipality.

Other interesting developments of the year tending to show the trend of the times were the beginning of operation of trackless trolleys in the Borough of Richmond and the municipal operation of the lines belonging to the Staten Island Midland Railway Company.

During 1921 the engineering department of the Transit Commission was engaged largely in making surveys and preparing designs, contracts, specifications and contract drawings in connection with such portions of the Dual Subway System as are not yet under construction. These lines include the extension of the Queensboro subway from Grand Central Station to Eighth avenue, a portion of the 14th Street-Eastern District line from Montrose and Bushwick avenues to Broadway, Brooklyn, and the Nassau Street line connecting the Center Street loop with the Montague Street tunnel. The work still unfinished includes also yards and terminals, inspection sheds, track and station-finish work.

During the year a very decided change in the law governing transit construction took place by reason of the enactment of Chapter 134 of the Laws of 1921, under the provisions of which a commission of three was substituted for the single-headed commission

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previously established. The new commission takes over temporarily at least the duties also of the former Public Service Commission of the First District.

The powers given to the Transit Commission are very broad—so broad in fact that the officials of the City administration raised a question as to whether the act was constitutional and this question has only been passed upon by the Court of Appeals within the past few days. Because of the change in the form of the commission and the position taken by the City authorities toward it, subway work has been practically at a standstill so that the year 1921 has been, as already stated, largely devoted to preparatory work in connection with unfinished lines.

The important engineering work of the Department of Water Supply, Gas and Electricity in 1921 has been the extension and improvement of the water-supply system, involving the expenditure of somewhat over $1,000,000. The department has requested for 1922 an appropriation of nearly $4,000,000 for improvements for all parts of the system.

In the early part of 1921, the Board of Estimate and Apportionment appropriated $900,000 for the reconstruction of High Bridge. This will involve some very interesting problems, including a masonry arch of over 200 feet span and over 100 feet clearance. The engineering problems involved in this change will require the services of additional engineers during 1922.

The consumption of water by the City continued during 1921 about the same as in 1920, totaling for the municipal system 685 million gallons daily as against 690 million gallons daily in 1920. About four-sevenths of this was drawn from the Catskill system, the remainder being mainly from the Croton system. It was necessary to again bring into regular use a portion of the Brooklyn system, and at the end of the year this system was delivering about 35 million gallons daily, or about one-fourth of its normal capacity.

The Board of Estimate and Apportionment has authorized the acquirement by condemnation of the Citizens Water Supply Company's system, which supplies the Second ward in Queens. The company asked about $4,000,000 for this system. Besides the Citizens Water Supply Company, there are four large private water companies supplying portions of Greater New York.

The necessity of studies being made for an additional water-supply which will be required some fifteen years hence, was pointed

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out to the Board of Estimate and Apportionment by the Department of Water Supply, Gas and Electricity, and the Board of Estimate authorized the Board of Water Supply to undertake such studies. The growth of the City is such that the Schoharie development, which will probably be available about 1925, will only suffice up to about 1936. The additional water-supply that will be required for the City will require the services of a large number of trained engineers, giving continuously to this problem their services for many years to come.

The year has been unusually active as regards local improvements in the various boroughs. The Board of Estimate and Apportionment gave final authorization for 344 assessable improvements of all kinds such as sewers, paving, regulating and grading, at an estimated aggregate cost of $14,345,000 as against 207 such improvements costing $5,000,000 in 1920. In connection with these improvements it is interesting to note a marked decrease in the prices bid for paving work during the course of the year. Between March and November this decrease amounted in some classes of pavement to as much as 33 per cent.

The membership of the Society shows a slight decrease in numbers for the year, this being accounted for in great measure by the sharp increase in those dropped for non-payment of dues. The financial condition is sound, the assets of the Society remaining about as they were in January, 1921. The technical papers presented by members and others were varied, interesting and instructive. Notable among these may be mentioned Mr. Tuttle's paper on "The Narrows Tunnel", Mr. Turner's on "Moving Platforms", Mr. Powell's on "City Planning in Queens" and Mr. Riedel's on "The Design of an Important System of Sewers in the Borough of Brooklyn".

In conclusion I desire to express my deep thanks to the Secretary and other officers of the Society, to the heads of committees and to the Board of Directors for the great aid that they extended to the President during the year just closing. Their attention to the affairs of the Society and particularly their attendance at meetings, many times at considerable sacrifice to their personal comfort, contributed in large measure to the success of our efforts. An earnest endeavor was made to maintain the Society's proceedings at the high standard heretofore set by former administrations and if we have succeeded in doing this, the results are due as I have said, to the unselfish work

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of those whom I have mentioned. In leaving the office of President which I have been very proud to hold, let me say that while I took it with some fears, I am departing with a feeling of thankfulness for the very great honor which the members conferred on me in making me their presiding officer for the year 1921.

MEETINGS

Abstracts from Past Meetings

BOARD OF DIRECTORS, January 21, 1922.—President Philip P. Farley presided. There were also present Messrs. Powers, Powell, Endemann, Tidd, Bell, Hunter, Riedel, Thomas, Ferris, Wood, Raisman, Dobbin, Borst, Koch and Moon.

The minutes of the meeting of December 28, 1921, were read and approved.

The Finance Committee's report submitting vouchers aggregating $403.67 was accepted and the bills ordered paid.

The annual reports of the Secretary, Treasurer, Finance Committee, Publication Committee, House Committee and Membership Committee were presented and accepted. The Annual Report of the Board of Directors to the Society was read and approved.

ANNUAL MEETING OF THE SOCIETY, January 25, 1922.—President Philip P. Farley presided and 300 members and guests were present. Ladies were invited to this meeting.

The minutes of the meeting of December 28, 1921, were read and approved.

The Annual Report of the Board of Directors to the Society was read and accepted.

The President's Annual Address was presented by Mr. Farley in which the work of the Society and the principal engineering projects engaged in by the City were briefly reviewed.

The speaker of the evening, Raymond L. Ditmars, Curator of the New York Zoological Park, was then introduced. Mr. Ditmars presented an address entitled "Solving the Mysteries of Nature", illustrated by five reels of motion pictures, in which the habits of the gorilla, chimpanzee, beaver, monkey and serpents were intimately shown together with many forms of marine life. The address was of a particularly interesting and instructive character.

The tellers appointed to canvass the ballots reported that 112 ballots had been cast, practically all in favor of the ticket as nominated, and the Chairman declared the following duly elected:

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	December 31, 1920	December 31, 1921
Total assets	$6,323.75	$6,335.39
Total liabilities	37.00	143.00
Excess of assets over liabilities	$6,286.75	$6,192.39

The ready assets of the Society on December 31, 1921, were:

Two Corporate Stock Bonds of The City of New York, face value $3,000, quoted at	$2,990.00	
Cash on hand	876.39	
		$3,866.39
Deduct:		
Outstanding obligations		143.00
Ready assets on December 31, 1921		$3,723.39
A comparison with last year shows:		
Ready assets on December 31, 1920		3,608.25
Excess over one year ago		$115.14

The Society has continued to occupy Room 601 in the Engineering Societies Building. Portions of the space therein have been rented to the American Engineering Council and to the American Society of Safety Engineers, this arrangement terminating with these societies on May 1 and December 1, respectively.

Under the direction of the Publication Committee, there have been presented during the year five topics of a technical character and three talks on popular subjects. At the Annual Meeting, Hudson Maxim delivered a popular address. The average attendance at the meetings has been practically unequaled in numbers in the history of the Society.

In June, through the courtesy of the Commissioner of Docks, an interesting inspection was made of the Staten Island piers at Stapleton, then in an advanced stage of completion.

The efficient manner in which the work of the remaining standing committees has been performed has served to maintain the interest of the members in the various activities.

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*Current Receipts and Disbursements:

	1920	1921
Current receipts	$4,236.41	$4,109.54
Current disbursements	4,197.68	4,218.40
Difference	+$38.73	—$108.86

Assets and Liabilities

(On December 31, 1921)

Assets		Liabilities	
Dues receivable	$1,555.00	Bills payable:	
Due from advertisements in Journal	63.00	Rent of meeting room	$40.00
Books in library	150.00	Assessment for storage space	12.00
Furniture	100.00	Printing	86.00
Office equipment	150.00	Miscellaneous	5.00
Proceedings in stock	225.00	Balance	6,192.39
Journals in stock	100.00		
One New York City 4½ per-cent. Corporate Stock. Market value on December 31, 103	2,060.00		
One New York City 4 per-cent. Corporate Stock. Market value on December 31, 93	930.00		
Cash with Treasurer	856.39		
Cash with Secretary	20.00		
Rental of Room 601	126.00		
Total	$6,335.39	Total	$6,335.39

Changes in Membership

(With a comparison with last year)

	1920		1921	
Membership on January 1	475		460	
Elected and paid dues	26		17	
		501		477
Died	7		4	
Resigned	24		25	
Dropped for non-payment of dues	10		26	
		41		55
Membership on December 31		460		422

* Balance on hand and extraordinary receipts and disbursements omitted.

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PERSONALS AND NOTES

A recently signed bill permits of mutual transfers of employees between a State department and a City department where the salaries of the State employees are paid entirely out of City funds, this, of course, applying to the Transit Commission.

The matter was presented to the Board of Directors and, in consequence and pursuant to action of the Society, the following communication was sent to the Committee on Judiciary of the State Assembly at Albany:

> "The Municipal Engineers of the City of New York, a society organized in 1902 for the purpose of promoting efficiency and harmonizing the engineering work of the several departments in the City of New York, comprising within its membership 500 engineers in the employ of the Transit Commission and in the Municipal service, considered Assembly Bill No. 979—Int. 938, at its meeting held on February 24, 1922.
>
> "Our Society endorses this proposed amendment of the Civil Service Law and urges its favorable consideration by your Committee."

The Professional Engineers License Law.—According to a ruling by the New York State Department of Education, under the Professional Engineers License Law, as amended by Chapter 581 of the Laws of 1921 and effective May 6, 1921, candidates are permitted to make application for certificates until May 6, 1923. There is some doubt as to whether or not all the provisions of the law have been postponed to become effective in 1923 as a result of the adoption of the amendment, and apparently it must be decided by the Attorney General of the State.

At least four bills or amendments have been recently introduced in the New York State Legislature affecting the Professional Engineers License Law, these bills being principally devised to exempt counties and towns from its application or else to repeal it altogether. All have the effect of practically nullifying the law and it is recommended that they be vigorously opposed.

The Twomey Bill, recently introduced in the New York State Senate (No. 270), authorizes the Board of Estimate and Apportionment to build a tunnel for the use of vehicles and pedestrians under Newtown creek, between Brooklyn and Queens.

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CONSTRUCTION OPERATIONS IN PROGRESS AT THE GILBOA DAM, WHICH WILL FORM THE 20-BILLION-GALLON SCHOHARIE RESERVOIR OF THE CATSKILL MOUNTAIN WATER SUPPLY FOR NEW YORK CITY. THE DAM IS BEING BUILT ACROSS THE SCHOHARIE CREEK AT A POINT 120 MILES FROM THE NEW YORK CITY HALL.

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MANOR KILL FALLS AT THE SCHOHARIE RESERVOIR OF THE CATSKILL MOUNTAIN WATER SUPPLY SYSTEM. THIS STREAM IS A TRIBUTARY OF THE SCHOHARIE CREEK, WHICH IS BEING DEVELOPED FOR NEW YORK CITY'S WATER SUPPLY. THE FALSEWORK SHOWN IS FOR THE MANORKILL STEEL HIGHWAY BRIDGE, WHICH WAS CONSTRUCTED BY THE BOARD OF WATER SUPPLY.

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HENRY WELLES DURHAM writes interestingly of the extensive construction work now under way by the Foundation Company of New York, at Lima, Peru. Mr. Durham has been in charge of the operations, which consist of water-supply, drainage and pavements, for about a year and a half.

High Cost of Rats.—The Fire Prevention Committee of the Building Managers and Owners Association of New York has issued the following bulletin to its members: "The up-keep of rats has gone up. A year or so ago, some one figured out that it costs us $1.80 per person per year to feed the rats in the United States. Recent figures compiled by a British expert place this cost in the United States at $750,000,000 a year, which is a trifle over $7.00 per person. This is simply for food consumed and destroyed and has nothing whatever to do with the very considerable fire loss they cause. Needless to say, we are urged as an economic measure to exterminate the rats; also you will recall what Dr. Royal S. Copeland had to say to us along this line last Winter as pertaining to public health. Viewed from all angles they are a menace."

Laurel Hill terrace, between West 181st and West 184th streets, Manhattan, along High Bridge park, will soon be graded; the contract, which will amount to about $86,000.00, will include a granite stairway entrance to the park.

Plans laying out Riverside Drive West, between 155th and 177th streets, at a new location west of the present one, have been forwarded to the Board of Estimate and Apportionment for approval. The new location will permit of more advantageous property development without depriving the drive of any of its artistic features. It is estimated that it will cost $2,250,000.00 to acquire the land and construct the drive.

The Department of Education is rapidly equipping its new quarters in the Tillery building at the Brooklyn end of the Manhattan bridge, and several departments have already moved in. Plans for nineteen elementary and four high schools are either being advertised or in course of preparation in accordance with the $70,000,000.00 building program recently approved.

The drafting force is being materially increased to take up the volume of work incident to the program which is being advanced with the greatest possible speed. C. B. J. SNYDER, as Superintendent of

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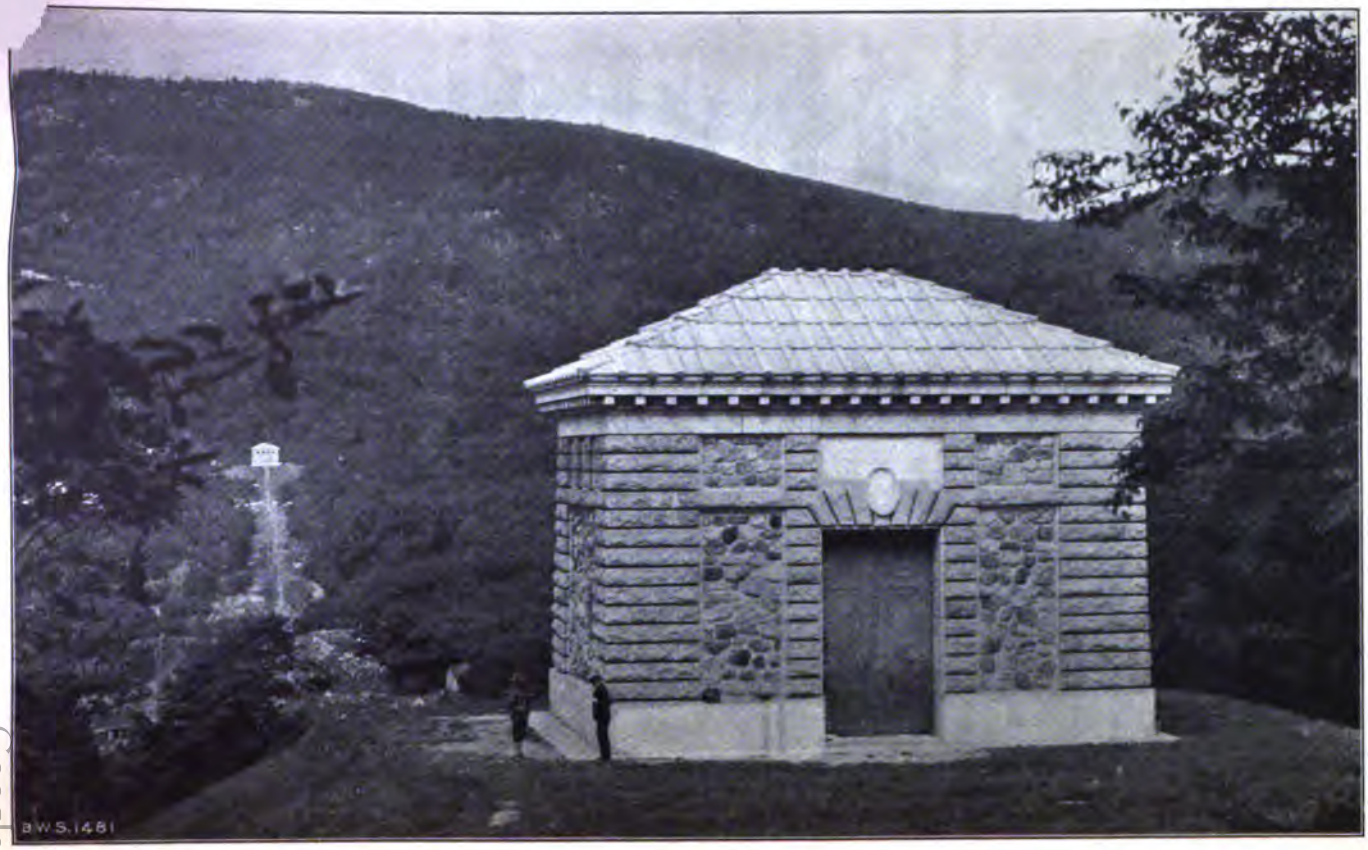

FOUNDRY BROOK SIPHON OF THE CATSKILL AQUEDUCT. ONE OF FOURTEEN LOCATIONS ALONG THE LINE OF THE AQUEDUCT WHERE THE CONSTRUCTION CONSISTS OF RIVETED STEEL PIPES ENCASED IN CONCRETE AND LINED WITH CEMENT MORTAR. ONE LINE OF PIPE IS NOW IN PLACE AT EACH OF THESE SIPHONS AND THE BOARD OF WATER SUPPLY HAS STARTED THE INSTALLATION OF THE REMAINING TWO PIPE-LINES AT EACH LOCATION IN ORDER TO COMPLETE THE AQUEDUCT. THE PIPES VARY FROM 7 FEET 4 INCHES TO 11 FEET 3 INCHES IN DIAMETER.

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School Buildings, is in charge of the preparation of the plans and specifications and the execution of the contracts, and CLARENCE E. DOBBIN is Deputy Superintendent.

At noon on February 2, the Narrows siphon suddenly ceased delivering Catskill Mountain water to the Silver Lake reservoir on Staten Island, and upon investigation it was found that this situation was caused by a break in the 36-inch flexible-jointed cast-iron pipe-line under New York harbor between the Boroughs of Brooklyn and Richmond. The break in the line occurred at a point about 170 feet from the Staten Island shore, where the pipe has an earth cover of 20 feet and is located at a depth of 50 feet below the surface of the water, the damage having been caused by the spud of a large dredge which was working in that vicinity at the time the break occurred.

This submerged pipe-line was constructed in 1914-1916 by the Board of Water Supply as a part of the City delivery system of the Catskill Mountain Water Supply at a cost of approximately one million dollars and is the main source of supply for the Borough of Richmond; it has a total length of about 10,000 feet and extends from 79th street, Brooklyn, to Arrietta street, Richmond.

As it was imperative that repairs should be made at once, the Merritt and Chapman Derrick and Wrecking Company, which concern had laid the pipe-line for the Board of Water Supply, was immediately asked to undertake the work of repair, and work was started within three hours after the damage had been sustained. After the pipe had been located, the broken section was removed by the use of an electric torch specially designed for submarine cutting operations and operated by divers, this work being completed on February 19, the actual burning of the pipe taking about nine days. Following the removal of the damaged portion of the line it was replaced with a new pipe length which was joined to the existing line by means of a cast-steel sleeve. The repairs were completed and water delivered to Staten Island at 3:15 P. M. on March 2. It is estimated that the repairs will cost about $60,000.

COME TO THE MEETINGS!

You wouldn't lay aside, unopened, your *Engineering News* simply because you failed to see anything in the table of contents that appealed to you. Of course not! Similarly, you should come to the meetings on general principles, regardless of whether the subject appeals to you or not. You will surely pick up some information as well as enjoy the refreshments. Bring a friend!

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PROGRESS REPORT OF THE COMMITTEE ON RAINFALL AND RUN-OFF

JANUARY 26, 1921.

To THE MUNICIPAL ENGINEERS OF
THE CITY OF NEW YORK.

GENTLEMEN: In 1913, your Committee on Rainfall and Run-Off presented a report comprising such of the information procured by the several boroughs of the City as was then available and believed of sufficient importance to preserve. Since then no report has been presented by the Committee owing to the lack of opportunity for its preparation; and while the same plea may be offered at this time with regard to a report involving original investigation, it has been thought advisable at least to bring the rainfall intensity records already compiled up to date. The results of this supplementary work are given in the accompanying tables which include the records of the United States Weather Bureau gage and the borough gages first at 115th street and later at 101st street, Manhattan, and of the Tottenville gage, Richmond, in addition to those included in the earlier report.

SELF-REGISTERING RAIN-GAGE RECORDS COMPRISED IN THIS REPORT

BOROUGH	LOCATION	DATES
Manhattan...	*Central Park	June 21, 1869 to Dec. 31, 1919
		Jan. 1, 1920 to Dec. 31, 1920
	†United States Weather Bureau, near Battery	April, 1896 to Dec. 31, 1920
	Bureau of Sewers—	
	115th street	Feb. 6, 1911 to .....
	101st street	Oct. 1, 1915 to Dec. 31, 1920
	98th street	Oct. 1, 1915 to Dec. 31, 1920
The Bronx...	Municipal Building	Nov. 13, 1904 to Dec. 31, 1920
Brooklyn.....	Mechanics Bank Building....	1906 to Dec. 31, 1920
Richmond....	New Brighton.....	1906 to Dec. 31, 1920
	Tottenville	1911 to Dec. 31, 1920

* In the published reports of this station there is given a table of "Large Precipitations of Water" for short durations. These are not applicable to the purposes of this discussion, as the amounts for all durations are computed from the same time for each storm. The tables given in the report give the maximum rate for different durations regardless of the part of the storm in which they occur.

† The intensities tabulated are limited to a selected list of the *most severe storm of each month*. High intensities may have occurred in other storms or for particular durations in the storms tabulated that do not appear on the list.

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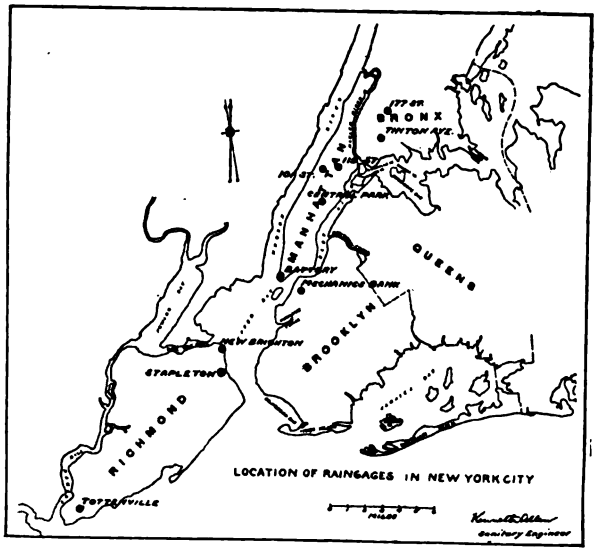

PLATE I—LOCATION OF RAIN GAGES IN NEW YORK CITY.

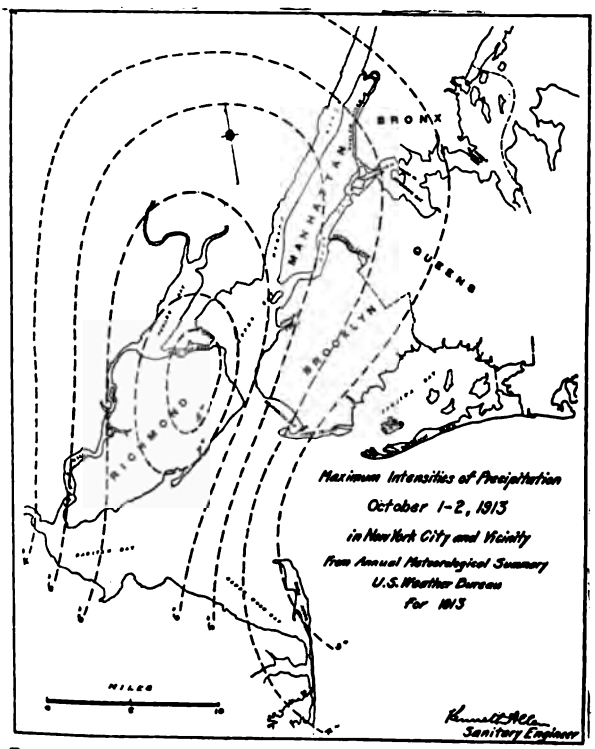

PLATE II—MAXIMUM INTENSITIES OF PRECIPITATION OCTOBER 1-2, 1913, IN NEW YORK CITY AND VICINITY.

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Plate I shows the relative location of the rain-gages in New York City. Plate III shows the intensities recorded in Manhattan that exceed the 15-year curve shown in the 1913 report.

About the time that the previous report of this Committee was presented in 1913, there occurred three storms of such remarkable magnitude that a discussion of them was inserted in the annual

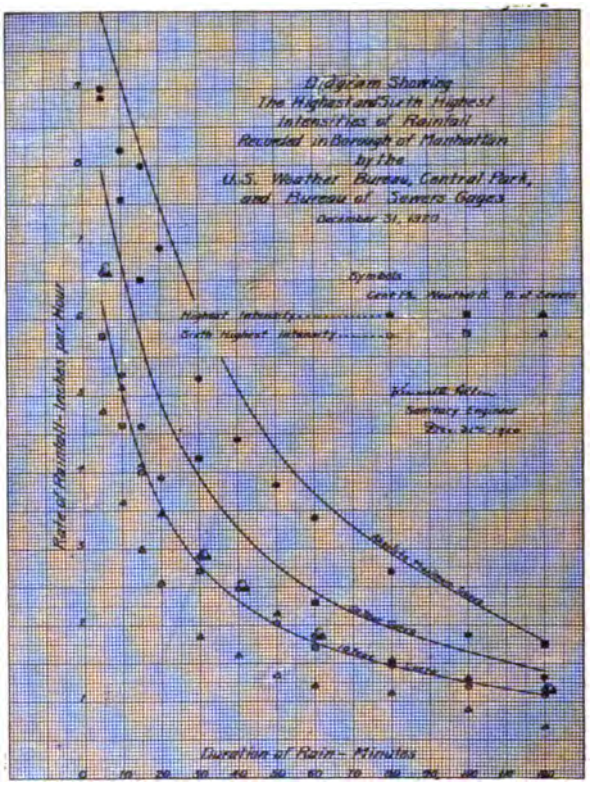

PLATE III—HIGHEST AND SIXTH HIGHEST INTENSITIES OF RAINFALL RECORDED IN BOROUGH OF MANHATTAN.

summary of the Weather Bureau for that year. This is believed to be of sufficient interest to justify the insertion of the following abstract:

THE HEAVIER RAIN STORMS OF 1913*

"An unusual series of excessive rain storms occurred in portions of New York City and vicinity on July 28th,

* Extracts from Annual Meteorological Summary, 1913, United States Weather Bureau.

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September 4th-5th, October 1st and October 24th-25th. June, July and August have heretofore been the months of greatest intensity of rainfall in short periods of time up to 2 hours, while September, October and November have been the months of greatest intensity for longer periods up to 24 hours. The storm of September 4th-5th established in lower Manhattan a new record of 2.82 inches in 2 hours, and the storm of October 1st again raised the 2-hour record to 3.34 inches. The storm of September 4th-5th established a new record for intensity of September storms for all periods from 5 minutes to 2 hours; and the storm of October 1st established a new intensity record for October storms for the same periods.

"The area involved in the excessive rain of July 28 was small, but at the New York Meteorological Observatory in Central park, 2.74 inches were recorded in one hour and 3.11 inches in 2 hours. This precipitation was from a local thunderstorm. The other heavy rains here considered were features of general storms which covered large areas, though the areas of excessive precipitation were not relatively large and the amounts within each excessive area varied considerably. In the storm of September 4th-5th, Central park had 3.31 inches in one hour and 3.70 inches in two hours, establishing new records at that station and probably for the City for those periods during the last 45 years.

"The storm of October 1st-2nd extended somewhat beyond the 24-hour period shown in the table and the area included a considerable portion of northeastern New Jersey and adjacent portions of New York, but in the latter apparently not extending much beyond the limits of Greater New York. The locality of heaviest precipitation was Staten Island. The total amounts for the storm, beginning the early morning of the 1st and ending the early morning of the 2nd, believed to be from reliable catch and measurement, are as follows:

Local office, United States Weather Bureau, 17 Battery place	5.19
Brooklyn Eagle	4.59
Central Park, Arsenal Building	5.11
Bronx Borough Hall	3.70
Bronx, 1517 Williamsbridge road	2.50
Staten Island, St. George, Borough Hall	8.47
Jersey City, N. J., 315 York street	6.13
Bayonne, N. J.	7.00
Newark, N. J.	6.40
South Orange, N. J.	4.16
Elizabeth, N. J.	4.88
Long Branch, N. J.	4.37
Paterson, N. J.	3.15

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"At Sandy Hook, N. J., the amount recorded from noon of the 1st to 6:08 A. M. of the 2nd was 1.55 inches, while at St. George, Staten Island, about 12 miles distant, the amount for the same period was 7.88 inches. Before that period the gage at Sandy Hook was out of order. Assuming that the amount before noon was similar to that at Long Branch, the total for the storm at Sandy Hook would be only about 3 inches.

"As nearly as can be determined from the records available, storms of equal intensity have not occurred in the last 45 years, but since 1869 storms of nearly equal intensity occurred in 1878, 1902, 1905 and 1913; so it is fair to assume that such storms are likely to average at least one in 10 years. It should be borne in mind that several such storms may occur in one year and there have been six such storms within the last 12 years. But there is nothing in the facts presented to warrant the assumption that such rains are becoming either more frequent or more intense.

"The following table shows the intensity of the four severe storms of 1913 at three points in Greater New York:

MAXIMUM INTENSITIES OF RAINFALL IN SHORT PERIODS OF TIME

Date and Place	5 Minutes	10 Minutes	15 Minutes	30 Minutes	1 Hour	2 Hours
July 28—						
17 Battery place	4.32	2.82	1.96	1.02	0.54	0.28
Brooklyn Eagle	1.80	1.38	1.12	0.58	0.32	0.18
Central Park Observatory	6.24	5.94	4.84	2.98	2.74	1.56
September 4-5—						
17 Battery place	4.32	3.84	3.44	2.74	2.00	1.41
Brooklyn Eagle	4.80	4.44	4.32	3.08	1.92	1.14
Central Park Observatory	7.20	6.90	6.36	5.24	3.31	1.85
October 1-2—						
17 Battery place	5.28	4.62	4.20	3.28	2.26	1.67
Brooklyn Eagle	3.72	3.12	2.88	2.46	1.59	1.16
Central Park Observatory	6.72	4.68	4.04	3.12	2.03	1.68
October 24-25—						
17 Battery place	1.44	1.26	1.08	0.86	0.54	0.38
Brooklyn Eagle	1.68	1.32	1.20	1.02	0.61	0.56
Central Park Observatory	2.64	2.22	1.88	1.42	0.83	0.59

In 1869, Dr. Daniel Draper established the first self-registering rain-gage in Central park. The record of over 52 years from this station is, therefore, available—the longest of its kind—and furnishes the best possible data from which to study intensities and frequencies in this vicinity.

A comparison of high intensities at different stations during the same storm indicates how restricted the areas are that are usually subject to the extreme intensities upon which our intensity curves

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and estimates of run-off are based. Table 8, for instance, gives the maximum intensities occurring at different points during the same day that intense down-pours occurred at the Central Park gage, and it is surprising to note the moderate rates recorded elsewhere.

Attention is also called to the storm of September 12, 1920, in which 0.49 inch fell between 3:00 and 4:00 P. M. at 101st street, Manhattan, 0.73 inch between 2:00 and 3:00 P. M. at Central park, and only 0.05 inch during the same interval at the Battery.

On the other hand, it is a question whether, in a long term of years, equally high rates would not have occurred at these other stations. There is an unfortunate lack of data upon which to assert the correctness or falsity of this assumption. But, owing to the importance of the Central Park record, a series of intensity curves has been prepared and are shown on Plate IV.*

These curves are based upon the probable frequency of years in which any given intensity will *not* be exceeded for periods of duration of from 5 to 120 minutes, as computed in accordance with methods of higher statistics employed in actuarial work.

During 1912 and 1913 gagings were made in the Borough of Richmond of the sewers in Broad street and Cedar street, Stapleton. Only those observations during the most severe storms of which a satisfactory and reliable record could be obtained in the sewer gages were plotted. The location of the sewer-gages and the rain-gage are shown on the map of the tributary area (Plate V). The rain-gage was of the "Draper" portable type. The divisions on the chart are one inch equals one hour and one inch equals one inch of rainfall. It was located on the flat roof of the fire-engine house at an elevation of 30 feet above the street level. There were no other buildings within a radius of 40 feet and no tall buildings or trees to interfere with a proper record of the rainfall.

The sewer-gages used were "Friez" water-stage registers. The depth of flow in the sewer was recorded by means of a copper float suspended in a 10-inch vertical pipe extending to the bottom of the sewer, and connected to it by a 10-inch horizontal pipe. The arrangement of it is shown on the section of the gaging-chamber.

The Cedar Street sewer-gage was fitted with a 24-hour chart on which a 1-hour space equals 7/24 inch, and 1-foot depth of flow equals 3 3/8 inches. It was placed in a manhole about 50 feet north of Broad street. The sewer is a combined sewer of egg-shaped section 3 feet 6 inches by 5 feet 3 inches, laid on a 0.5 per cent. grade;

* These curves have been proposed for the City by the Chief Engineer's office of the Board of Estimate and Apportionment. *Ed.*

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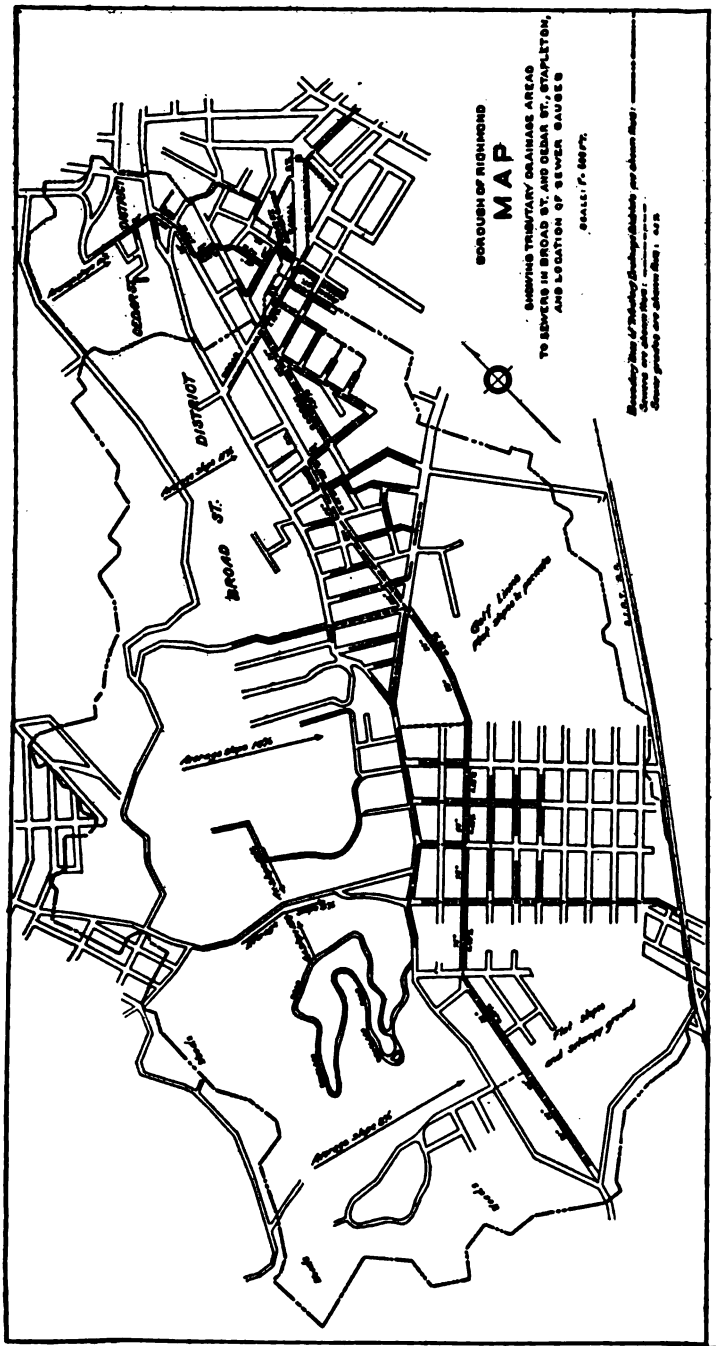

PLATE V—TRIBUTARY DRAINAGE AREAS TO SEWERS IN BROAD AND CEDAR STREETS, STAPLETON, STATEN ISLAND, AND LOCATIONS OF GAGES.

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it is straight and uniform in cross-section from a point 50 feet below the gage to a point 150 feet above it, and there are no basin inlets or sewer junctions within these limits. It was built in 1910 and the vitrified-brick lining in the invert and concrete surface above it are in first-class condition. The amount of flow was computed from the recorded depth of flow by Kutter's formula with $n = 0.013$.

The tributary area is of a residential character; it has steep slopes. The streets are paved. The soil is red clay with outcrops of serpentine rock in the upper sections of the district.

Total area	76.8 acres
Number of houses	342
Estimated population	2,500
Roof area	13 per cent. of total
Paved area	11 per cent. of total
Hard-soil area	6 per cent. of total
Grass and cultivated land	70 per cent. of total
Length of area	2,600 feet
Average width of area	1,400 feet

The average slope of land from the gage to the furthest point is 8 per cent.

In the computation of flow, the dry-weather flow was subtracted. The time of run-off through the sewer from the most remote inlet to the sewer gage, under maximum conditions of velocity, was computed to be six minutes. The period of concentration of maximum flow to the most remote inlet was estimated as ten minutes.

Assuming the imperviousness of roofs as 90 per cent., pavements 80 per cent., hard soil 25 per cent. and of grass and cultivated land as 15 per cent., the total area has an imperviousness of 32.5 per cent.

During the period of observation the maximum run-off has been computed for four severe storms with the following results:

Observed Percentage of Run-Off.—I = Mean rate of precipitation on drainage areas during the 16 minutes of greatest intensity, in cubic feet per second per acre; Q = Maximum flow in sewer in cubic feet per second per acre; C = Per cent. run-off:

Date	I	Q	C
October 23, 1912	2.68	0.54	20.2
November 1, 1912	1.20	0.475	39.6
March 26, 1913	0.855	0.28	32.8
October 1, 1913	1.56	0.52	33.3

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The rate of precipitation from which the last result was computed was 2.04 inches per hour for 5 minutes, followed by 1.34 inches per hour for 11 minutes. The latter rate was maintained 6 minutes longer and was followed by 1.20 inches per hour for 5 minutes, 4.50 inches per hour for 4 minutes and 3.60 inches per hour for 5 minutes, when the capacity of the gage was exceeded.

The flow in the sewer fell from 0.52 to 0.275 cubic foot per second per acre in 11 minutes and then increased to 0.65 cubic foot per second per acre in 2 minutes and to 1.51 cubic feet per second per acre in 12 minutes more, when the sewer became surcharged from the trunk sewer below. Owing to uncertainty in synchronizing the rain and sewer gages, it does not appear possible to determine the run-off factor in this remarkable down-pour subsequent to the time when the discharge was 0.52 cubic foot per second per acre.

The Broad street sewer-gage was fitted with a 7-day chart on which 1-hour space equals 1/24 inch and 1-foot depth of flow equals 3 3/8 inches. It was placed in a manhole about 80 feet west of Cedar street. The sewer is a combined sewer of basket-shaped section 7 feet high and 10 feet 6 inches wide. It has a vitrified-brick invert and concrete side-walls and roof. It was built in 1910 and is in first-class condition. Its grade is 1.14 per cent. It is straight and uniform in cross-section and grade and has no street inlets or sewer junctions from a point 110 feet below the gage to a point 125 feet above it. The amount of flow was computed by Kutter's formula with $n = 0.013$. The dry-weather flow was subtracted. The tributary area is, with the exception of Broad street, which is of business character, a residential section. The outer parts of the district are only sparsely built up. The soil is largely clay. There is serpentine rock along the westerly boundary of the district. The sewers have not yet been extended to the outer ends of the district, where the drainage is through ditches and natural water-courses.

A considerable amount of rain-water collects in depressions and does not readily reach the sewer.

Total area	900 acres
Number of houses	1,258
Estimated population	7,500
Roof and paved area	7 per cent. of total
Hard soil	2 per cent. of total
Grass and cultivated land	72 per cent. of total
Woodland	19 per cent. of total

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Length of area.....10,000 feet
Average width of area.....4,000 feet

The average slope of the land along the line of the trunk sewer from the furthest point to the sewer-gage is 0.8 per cent. There are steep slopes along the westerly boundary of the district averaging 9 per cent. The time of run-off through the sewer from the

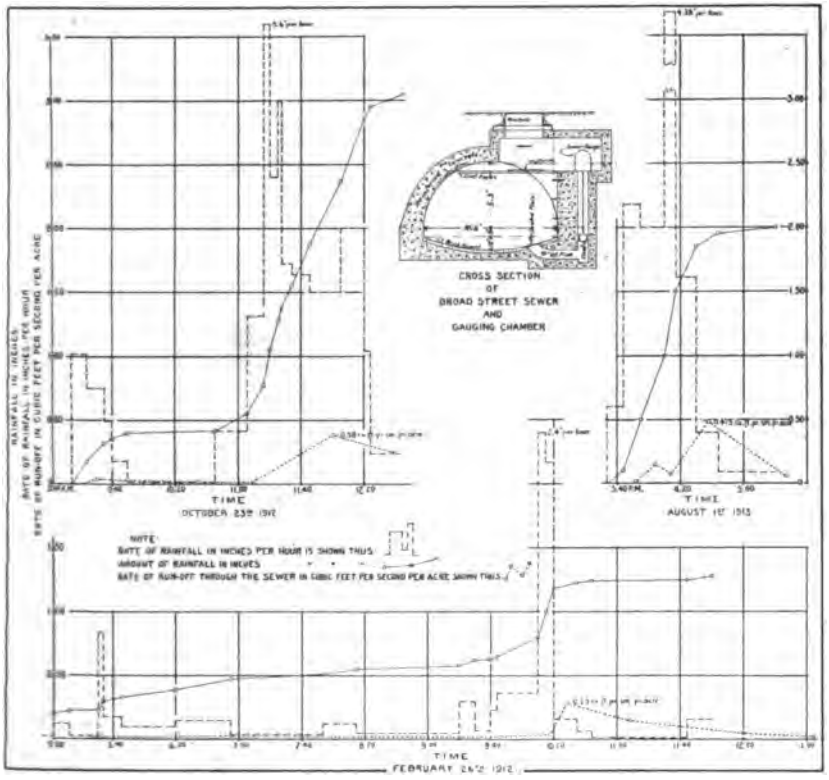

PLATE VII—CROSS-SECTION OF BROAD STREET SEWER AND GAGING-CHAMBER, STAPLETON, STATEN ISLAND. RAINFALL AND RUN-OFF RECORDS FOR STORMS OF FEBRUARY 26, 1912, OCTOBER 23, 1912 AND AUGUST 1, 1913.

most remote inlet to the sewer-gage, under maximum conditions of velocity, was computed to be 11 minutes, and the period of concentration of maximum flow to this inlet 13 minutes.

Assuming the imperviousness of roofs and pavements as 90 per cent., hard soil as 25 per cent. and grass and cultivated land as 15 per cent., the area as a whole is 20.5 per cent. impervious.

The run-off from this area has been computed for three selected storms.

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Observed Percentage of Run-Off.—I = Mean rate of precipitation on the drainage area during the 24 minutes of greatest intensity, in cubic feet per second per acre; Q = Maximum flow in sewer in cubic feet per second per acre; C = Per cent. run-off:

Date	I	Q	C
February 26, 1912.....	1.16	0.29	25.0
October 23, 1912.....	2.32	0.38	16.4
August 1, 1913.....	2.08	0.475	22.8

Owing to the small-scale divisions of the time element on the record sheets of the sewer and rain gages, it has been difficult to establish the exact relations of the time of heaviest intensity of rainfall to that of the maximum run-off in the sewer. For this reason, the records are not considered as being conclusive. Instruments showing the time element to a larger scale are desirable.

The storm of October 1, 1913, showed intensities of rainfall varying sharply over small areas, as was evidenced by the records of the rain-gages at Borough Hall, New Brighton and Stapleton. This probably explains why the run-off curve of that storm does not follow entirely the rainfall intensity curve.

The above results of run-off experiments on the Cedar street and Broad street drainage areas should not be considered final. In order to draw reliable conclusions, further gagings should be made and it is gratifying to know that these are being continued, so that we may look forward to the establishment in the future of run-off coefficients that may be used with confidence for similar areas.

Further information concerning the run-off factor—more specifically, the maximum capacity required for a storm-water drain or combined sewer serving a given area—is to be desired. Experiments have been made to determine this factor in various cities—Rochester, N. Y., Philadelphia, Pa., St. Louis, Mo., Toronto, Canada, etc.—and results obtained elsewhere should be utilized to the fullest extent; but owing to the time and expense involved, or to uncertainty as to local conditions, the reliability of gagings, etc., a very small proportion of the material that has been published can be used with confidence. Moreover, any experiments on run-off apply only to other areas of similar character. Information directly applicable to all conditions cannot be expected and all that can be done in any case

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is to add something to the knowledge of the subject already available.

New York has done some notable work in this direction in the past in the gagings of the Sixth Avenue or "Minetta Brook" sewer by Rudolph Hering in 1888, and in those of the Tinton Avenue sewer by the Borough of The Bronx described in the report of this Committee in 1913, but the economical importance of a correct basis of sewer design is so great that it is the opinion of your Committee that the City should take up further work in this direction. This would involve the maintenance of one or more self-recording raingages on each area selected and the record of all excessive rates of run-off for a term of years. Too much emphasis cannot be given to the necessity of an accurate description of the conditions of soil, the development of the area and its topography, and for a reliable measurement of the flow in the sewer—conditions not easy to comply with but essential if the results are to have any real value.

With this in mind, the Committee would respectfully recommend that the Municipal Engineers of the City of New York memorialize the Board of Estimate and Apportionment to take measures to promote the carrying out of rainfall and run-off experiments in one or more of the boroughs and under such authority as may seem to the Board advisable.

Finally, your Committee desires to place on record its sense of loss, not only to the Committee but to the Society and to the community at large, in the sudden death of Harold Tait on November 29, 1920.

Respectfully submitted,

KENNETH ALLEN,
Chairman,
JOHN C. RIEDEL,
WALTER W. COHEN,
VICTOR H. REICHELT,
EDWARD W. WOOD.

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TABLE 1

MAXIMUM STORMS—UNITED STATES WEATHER BUREAU GAGE, NEAR THE BATTERY, MANHATTAN

MAXIMUM STORMS 1896 to 1920 incl.
U. S. Weather Bureau Gage - Battery.

RATE OF RAINFALL IN INCHES PER HOUR

DUR. IN MIN.	5	10	15	30	60	120
June 1896	2.28	1.86			0.56	
July 1896	4.80	3.48			1.04	
August 1896	2.28	1.92			.59	
Sept. 1896	2.83	1.62			.47	
May 1897	2.40	2.16			.68	
June 1897	5.04	3.42			.69	
July 1897	3.36	2.40			.85	
August 1897	3.82	2.76			.75	
April 1898	3.12	1.80			.36	
July 1898	4.08	2.64			1.27	
August 1898	2.88	1.56			.41	
October 1898	4.32	3.18			.57	
June 1899	1.92	1.50			.46	
July 1899	3.24	2.94			1.42	
August 1899	3.72	2.58			1.20	
Sept. 1899	2.54	2.22			.95	
May 1900	2.16	1.68			.98	
June 1900	3.12	3.00			1.55	
July 1900	4.08	2.46			.65	
August 1900	1.92	1.62			.47	
October 1900	2.04	1.62			.88	
March 1901	1.44	1.32			.64	
July 1901	4.56	3.78			1.29	
August 1901	5.76	4.92			1.36	
Sept. 1901	3.00	1.74				
June 1902	2.64	2.16			.67	
July 1902	5.64	4.38			.88	
August 1902	4.44	3.90			1.01	
October 1902	2.28	1.92			.57	
June 1903	3.60	2.46	1.92	1.48	1.30	0.97
July 1903	2.76	2.34	1.68	1.00	.50	
August 1903	1.20	0.66	0.60	.50	.46	.42
Sept. 1903	1.68	1.50	1.16	.82	.84	.55
October 1903	3.36	2.46	2.60	1.98	1.49	1.21
July 1904	2.28	1.62	1.08	0.96	0.59	0.32
August 1904	4.80	3.84	3.12	2.36	1.66	.90
Sept. 1904	3.00	2.28	1.60	1.22	.80	.58
October 1904	1.44	1.14	1.04	.76	.66	.57
June 1905	4.56	3.66	2.64	1.32	.66	.44
July 1905	8.88	7.56	6.52	4.18	2.30	1.28
August 1905	2.40	2.16	1.92	1.60	.98	.49
Sept. 1905	2.40	1.62	1.34	1.20	1.00	.69
April 1906	1.20	1.08	.96	.72	.64	.46
May 1906	4.20	3.54	2.72	1.54	.94	.83
July 1906	2.28	1.68	1.32	.88	.64	.35
August 1906	6.24	5.82	4.88	2.70	1.36	.68
Sept. 1906	1.92	1.86	1.88	1.26	.89	
October 1906	2.28	1.50	1.24	.66		
August 1907	2.24	1.80	1.80	1.32	.84	.49
Sept. 1907	2.64	1.98	1.60	1.18	.68	.42
May 1908	2.88	2.04	1.56	.90	.81	.58
July 1908	4.68	2.94	3.00	2.28	1.22	.76
August 1908	1.80	1.74	1.20	.94	.74	.62
October 1908	2.52	1.86	1.60	1.16	.64	.33
July 1909	2.16	1.56	1.24	.66		
Dec. 1909	1.44	1.20	.96	.94	.66	.49
June 1910	3.00	2.46	1.92	1.16	.63	.47
August 1910	2.64	2.58	2.20	1.40	.73	.37
October 1910	2.16	1.80	1.68	1.40	.91	.66
Feb. 1911	1.56	1.02	.84	.62	.53	.40
June 1911	2.40	1.92	1.60	1.06	.95	.52
August 1911	1.92	1.68	1.36	.88	.53	.36
Feb. 1912	3.72	2.58	1.80	1.00	.57	.31
July 1912	5.28	4.62	4.00	2.94	1.74	.93
August 1912	6.00	5.66	2.68	1.46	.81	.45

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TABLE 1 (*Concluded*)

MAXIMUM STORMS 1896 to 1920 incl.
U. S. Weather Bureau Gage - Battery.

RATE OF RAINFALL IN INCHES PER HOUR

DUR. IN MIN.	5	10	15	30	60	120
			(CONTINUED)			
October 1912	3.12	2.22	2.00	1.88	1.70	1.13
June 1913	2.16	1.92	1.88	1.36	0.77	0.39
July 5 1913	5.16	4.68	4.00	2.12		
" 28 1913	4.32	2.82	1.96	1.02	.54	
Sept.4)						
5) 1913	4.32	3.84	3.44	2.74	2.00	1.41
Oct.1-2 1913	5.28	4.62	4.20	3.28	2.26	1.67
Mar.1-2 1914	0.60	0.48	0.24	0.48	0.45	0.45
Jul.1-2 1914	2.04	1.44	1.16	.78	.61	.58
Aug. 21 1914	3.36	3.30	2.88	1.90		
Oct.16-17 1914	2.04	1.26	0.88	.50	.36	.25
June 15)						
" 16) 1915	1.56	1.26	1.08	0.94	0.81	
June 30 1915	1.92	1.86	1.80	1.50	1.10	.66
July 5 1915	3.72	2.76	2.52	1.66	.92	
July 22 1915	3.24	2.88	2.28	1.74	1.05	.58
Sept.17 1915	2.64	2.28	1.80	.92	.46	.23
June 16)						
" 17) 1916	4.20	3.00	2.00	1.00	0.50	0.25
Sept.29 1916	3.12	2.28	1.88	.98	.54	.32
June 14 1917	4.32	3.90	3.88	3.34	2.00	1.75
July 12 1917	3.60	3.30	3.04	2.06		
July 22 1917	5.88	5.76	4.48	3.20		
Aug. 23)						
" 24) 1917	4.56	2.40	1.64	.88	.44	.24
Sept. 1 1917	1.56	1.50	1.32	1.10	.88	.70
May 21 1918	3.84	2.58	1.88	1.04		
June 7 1918	3.00	1.68	1.28	.98	.65	.41
July 30)						
" 31) 1918	1.56	1.44	1.40	1.08	.77	.77
Nov. 17)						
" 18) 1918	2.88	1.80	1.24	.62	.39	.39
July 19)						
" 20) 1919	2.88	2.58	2.24	1.24	0.99	0.58
July 31)						
Aug. 1) 1919	1.32	2.16	2.00	1.20	.67	.39
Aug. 15 1919	5.04	3.90	3.36	2.16		
Aug. 17)						
" 18) 1919	2.04	1.86	1.80	1.24	.87	.54
June 24 1920	6.00	3.96	2.92	1.98	1.34	0.67
July 24 1920	4.92	3.42	2.60	1.56	0.94	.56
Aug. 16 1920	4.56	3.42	2.88	2.04	1.13	.58

Prior to June 1913 the highest intensity occurring in any storm during the month was recorded.

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TABLE 2

MAXIMUM STORMS—GAGES 1, 2 AND 3, MANHATTAN

MAXIMUM STORMS Feb. 4, 1911 to Dec. 31, 1920
GAGES NOS. 1, 2, and 3 - MANHATTAN.

RATE OF RAINFALL IN INCHES PER HOUR.

DUR.	IN MIN.	5	10	15	20	30	40	50	60	80	100	120	GAGE
June 10	1911	4.44	3.30	2.44	1.89	1.28	0.98	0.82	0.73	0.60			1
June 12	1911	4.44	3.60	2.76	2.16	1.56	1.32	1.16	1.14	0.87	0.71	0.61	"
July 21	1911	3.00	2.70	2.20	1.89	1.30	0.98	0.79	0.67	0.51	0.41	0.37	"
Aug. 15	1911	3.60	3.48	3.00	2.86	2.22	1.71	1.38	1.15	0.96			"
Oct. 19	1911	1.08	0.90	0.84	0.81	0.74	0.71	0.68	0.68	0.68	0.86	0.82	"
Feb. 26	1912	3.00	2.40	1.72	1.38	1.06	0.86	0.74	0.68	0.57	0.46	0.39	"
May 30	1912	3.60	3.18	2.40	1.86	1.26	0.96	0.78	0.66				"
July 31	1912	3.84	2.64	1.92	1.50	1.00	0.78	0.61	0.51	0.41	0.33		"
Aug. 11	1912	2.76	2.10	1.64	1.50	1.22	0.96	0.79	0.68				"
Oct. 23	1912	2.28	1.50	1.20	1.06	1.06	1.08	0.96	0.92	0.84	0.76	0.67	"
Mar. 26	1913	2.52	1.92	1.60	1.35	1.14	1.02	0.88	0.80	0.65	0.53		"
June 7	1913	2.88	2.28	1.68	1.38	1.00	0.77	0.62	0.53				"
July 5	1913	3.00	2.70	2.32	2.04	1.44							"
July 24	1913	4.80	4.20	3.16	2.52	1.68	1.26	1.10	1.32	1.10	0.86		"
July 28	1913	4.80	3.30	2.80	2.40	1.84	1.64	1.58	1.39	1.13	0.91		"
Aug. 1	1913	2.16	1.68	1.40	1.20	1.00	1.05	0.88	0.75	0.57	0.47		"
Aug. 7	1913	2.40	2.40	2.80	1.95	1.54	1.20	1.00	0.85	0.67	0.56	0.50	"
Oct. 1	1913	6.60	5.10	4.08	3.45	2.90	2.48	2.15	1.85	1.52	1.31	1.17	"
Oct. 8	1913	1.68	1.68	1.44	1.41	1.12	0.98	0.90	0.95	0.81			"
Oct. 20	1913	1.20	0.96	0.80	0.78	0.70	0.68	0.66	0.65	0.59	0.52	0.45	"
Oct. 25	1913	2.04	1.68	1.40	1.44	1.26	1.01	0.86	0.77	0.62	0.53	0.53	"
June 29	1914	2.76	2.04	1.72	1.38	0.96							"
July 2	1914	2.04	1.74	1.48	1.20	1.00	1.08	0.98	0.90	0.85	0.74	0.71	"
July 7	1914	3.60	2.40	1.84	1.74	1.42	1.29	1.14	1.03	0.86	0.69	0.58	"
Aug. 21	1914	5.16	4.80	3.48	2.85	2.24	1.74	1.43	1.22	0.94	0.77	0.65	"
June 30	1915	2.52	2.16	1.92	2.10	1.90	1.59	1.33	1.13	0.89	0.79	0.66	"
July 5	1915	3.96	3.60	2.68	2.10	1.46	1.23	1.02	0.86	0.67	0.54	0.45	"
Aug. 4	1915	2.28	1.92	1.80	1.71	1.52	1.34	1.21	1.14	1.10	1.00	0.98	"
June 17	1916	5.40	4.50	3.40	2.64	1.80	1.35	1.28	1.17				3
July 27	1916	1.80	1.80	1.68	1.59	1.20							"
Aug. 8	1916	3.12	1.98	1.84	1.44	1.06	0.80	0.64	0.57				"
Oct. 5	1917	5.88	3.30	2.28	1.74								"
Dec. 8	1917	1.20	1.20	1.20	1.11	1.04	1.01	0.97	0.91	0.77	0.65	0.57	"
May 10	1918	1.80	1.50	1.44	1.20	1.10	0.95	0.77	0.65	0.52	0.43	0.38	1
May 21	1918	2.04	1.56	1.28	1.14	1.00	0.81						2
June 7	1918	2.40	2.16	2.04	1.89	1.50	1.44	1.32	1.19	0.92	0.76	0.65	3
July 6	1918	3.00	1.74										2
July 30	1918	3.36	2.88	2.40	2.10	1.62	1.31	1.14	0.95	0.76			3
Aug. 14	1918	4.80	3.00	2.64	2.07								1
Aug. 29	1918	3.12	2.70	1.84	1.38	0.94	0.74	0.60	0.50	0.45	0.47		"
June 20	1919	4.80	4.20	3.28	2.58	1.80	1.41	1.14	0.96	0.73	0.59	0.50	3
June 27	1919	1.80	1.68	1.80	1.59	1.50	1.43	1.26	1.10	0.86	0.76	0.67	2
July 16	1919	2.88	2.28	1.84	1.62	1.34	1.30	0.94	0.85	0.66	0.55	0.47	3
July 26	1919	3.24	2.82	2.60	2.55	2.32	1.97	1.65	1.60	1.23	0.99	0.84	1
Aug. 1	1919	1.56	1.38	1.16	1.14	1.14	0.89	0.74	0.63	0.53	0.46	0.39	3
Aug. 18	1919	1.80	1.44	1.24	1.05	0.96	0.84	0.72	0.63	0.53	0.43	0.38	2
Aug. 25	1919	3.60	2.22	1.52	1.20	1.00	0.78	0.66	0.56	0.46			3
Sep. 23	1919	1.68	1.62	1.52	1.44	1.38	1.32	1.22	1.14	1.14	1.10	1.01	2
July 24	1920	2.88	2.64	2.36	2.04	1.44	1.10	0.91	0.89	0.71	0.61	0.61	3
Aug. 11	1920	2.28	1.92	1.60	1.32	1.02	0.78	0.62	0.53	0.40	0.36	0.36	"
Sep. 12	1920	2.76	2.34	1.80									"
Sep. 28	1920	2.28	1.86	1.32	0.99	0.68	0.57	0.53	0.45				"

Gage #1 on 115th Street, 100 feet east of Lenox Avenue, estab. Feb. 1911
Gage #2 at 98th Street and Amsterdam Avenue, established Aug. 1915
Gage #3 at 101st Street and Columbus Avenue, established Aug. 1915
Subsequent to Aug. 20, 1915 the record is taken from the gage deemed to have the most reliable record, usually the one showing the maximum.

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TABLE 3

Maximum Storms—Municipal Building Gage, The Bronx

MAXIMUM STORMS 1914 to 1920 incl.
MUNICIPAL BUILDING GAGE - THE BRONX

RATE OF RAINFALL IN INCHES PER HOUR

DUR. IN MIN.	5	10	15	20	30	40	50	60	80	100	120
June 29 1914	2.04	1.44	1.20	.93	.64						
July 2 1914	2.16	1.86	1.68	1.47	1.26	1.26	1.14	1.04	.89	.79	.74
July 7 1914	2.28	1.50	1.32	1.05	.76	.60	.50	.47	.47		
July 17 1914	6.60	4.02	2.72	2.04	1.38	1.06					
Aug. 21 1914	3.36	1.98	1.44	1.26	1.00	.78	.66n	.58	.46		
June 26 1915	2.04	1.80	1.36	1.05	.84						
June 30 1915	4.20	3.30	2.80	2.55	2.16	1.74	1.46	1.26	.98	.82	.73
Aug. 4 1915	2.04	1.74	1.64	1.53	1.32	1.26	1.14	1.11	1.05	.98	.95
Aug. 21 1915	2.16										
May 27 1916	1.92	1.02	.72	.57	.40						
June 17 1916	3.60	3.30	3.00	2.70	1.94						
June 17 1916	2.40	1.92	1.52	1.17							
July 13 1916	2.04	1.62	1.12	.87	.64	.50	.41	.37	.29	.26	.24
Aug. 6 1916	1.92	1.50	1.20	1.20	1.14	.87					
Sep. 23 1916	2.40	1.44	1.00	.84							
Sep. 29 1916	1.80	1.62	1.12	.84	.70	.54	.46	.39	.32		
June 14 1917	2.04	1.80	1.56	1.29	.94	.72					
June 23 1917	2.40	1.92	1.36	1.05							
Aug. 24 1917	2.40	1.26									
Apr. 21 1918	1.80	1.56	1.20	1.05	.72	.57		.44			
June 7 1918	2.16	1.50	1.32	1.17	1.06	1.12	1.00	.86			
July 6 1918	3.12	2.22									
July 6 1918	1.08										
Aug. 2 1918	3.60	2.04	1.46	1.26	1.18	1.19	1.15	1.12	.87	.76	.64
Aug. 29 1918	1.80										
Aug. 29 1918	2.04	1.38	1.00	.75	.52	.62		.42			
Sep. 18 1918	1.80	1.50	1.14	.90	.66	.51		.38			
May 7 1919	1.32	1.26									
May 24 1919	2.25										
June 20 1919	3.60	2.70	2.60	2.25	1.82	1.38		.92			
July 16 1919	2.40	1.80	2.00	1.59	1.18	.93		.66			
July 22 1919	3.00	2.34	1.60	1.32	.94	.74		.52			
July 26 1919	1.92	1.68	1.64	1.44	1.50	1.30	1.13	1.14	1.04	.93	.83
Aug. 12 1919	1.44	1.26	1.08								
Aug. 18 1919	1.32	1.26	1.12	1.00							
Aug. 23 1919	2.76										
Aug. 23 1919	4.08	2.22	1.76	1.38	1.06	.87		.60			
Aug. 30 1919	1.74	1.50	1.04								
Sep. 22 1919	1.80	1.50	1.48	1.41	1.36	1.26	1.20	1.15	1.04	1.02	.93
Oct. 16 1919	3.72	2.40	1.80	1.61							
Nov.4-5 1919	1.80	1.50	1.28	1.02							
Apr. 7 1920	2.28										
May 20 1920	1.80	1.50	1.32	1.08	.90	.72	.58	.51			
June 17 1920	1.44	1.32	1.08	.90	.66	.54					
June 29 1920	4.44	3.60	2.92	2.25	1.60	1.23	.98	.82	.62	.51	.58
July 23 1920	1.68	1.50	1.40	1.35	1.14	1.01	1.01	.97	.74	.61	.56
Aug. 10 1920	4.20	3.30	2.56	2.25	1.90	1.37	1.10	.97	.73	.58	.48
Aug. 11 1920	2.40	1.74	1.60	1.26	.94	.75	.55	.51	.48	.44	.40
Aug. 15 1920	4.56	3.36	2.84	2.46	1.98	1.50	1.20	1.04	.81	.74	.68
Sep. 12 1920	3.12	2.58	1.80	1.38	1.00	.75	.64	.54	.46	.38	.32
Sep. 28 1920	1.56	1.80	.93	.62	.54	.43					
Sep. 29 1920	3.60	2.64	1.76	1.32	.96	.92	.74	.64	.48	.39	.37
Sep. 30 1920	4.80	3.00	2.04	1.56	1.04	.91	.74	.54	.44	.46	.42
Oct. 16 1920	1.80	1.44	1.12	.87	.64	.50					

No observations taken in the winter.

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TABLE 4

MAXIMUM STORMS—UNITED STATES WEATHER BUREAU GAGE, EAGLE BUILDING, BROOKLYN

MAXIMUM STORMS 1914 to 1920 incl.
U. S. WEATHER BUREAU GAGE, EAGLE BLDG., BROOKLYN.

		RATE OF RAINFALL IN INCHES PER HOUR						
DUR. IN MIN.	10	20	30	40	50	60	120
July 23 1914	1.662	.909	.630	.479	.385	.323	.163
Aug. 11 1914	2.790	2.400	2.000	1.608	1.286	1.072	
Aug. 21 1914	3.204	2.052	1.722	1.331	1.132	.973	.527
Nov. 15 1914	1.380	1.149	.822	.683	.582	.501	.258
May 22 1915	1.500	1.050	1.380	1.210	.996	.885	.49
June 30 1915	1.320	.960	1.520	1.335	1.450	1.210	.695
July 5 1915	4.080	2.370	1.990	1.600	1.310	1.10	.570
July 17 1915	2.460	1.320	.900	.698	.558	.465	.235
Aug. 4 1915	1.140	1.680	1.800	1.560	1.420	1.36	1.065
Sep. 17 1915	2.580	1.560	1.060				
Sep. 21 1915	1.860	.990	.670	.503	.402	.340	.185
June 19 1916*	1.63	1.14	.76	.57	.52	.53	
Aug. 8 1916	1.50	.96	.66	.50	.41	.34	
Sep. 8 1916	1.38	.84					
Sep. 15 1916	1.26	.63	.44	.35	.28	.23	.17
Sep. 15 1916	1.62	1.05	.74	.56	.49	.41	.26
Sep.18-19 1916	2.59	1.71	1.14	.86	.70	.58	.32
Sep. 23 1916	1.69	.87	.60				
Sep. 29 1916	1.63	1.08	.74	.56	.48	.41	.25
June 14 1917	3.79	3.12	2.74	2.44	2.36	2.22	1.51
June 29 1917	2.11	1.65	1.10				
July 12 1917	2.41	2.16	1.64	1.23	.98	.82	
July 14 1917	1.87	1.38	1.14	.96	.80	.68	.39
July 22 1917	4.46	3.24	2.40	1.82	1.45	1.22	
Oct. 12 1917	1.38	.78	.64	.54	.49	.44	.31
June 7 1918	1.99	1.35	1.06	.81	.79	.72	
June 21-22 1918	1.32	.81	.74	.69	.60	.54	.37
Aug. 1 1918	1.57	1.56	1.12	1.20	1.08	.98	.61
Aug. 12 1918	1.39	.87	.60	.45	.36	.31	.16
May 24 1919	2.04						
June 20 1919	1.98	1.26	1.10	1.03	.73	.64	.42
July 20 1919	2.52	1.86	1.38	1.08	.89	.75	.46
Aug. 15 1919	4.14	3.42	2.56	1.98	1.77	1.49	
Aug.17-18 1919	1.86	1.59	1.44	1.26	1.14	1.02	.66
Oct. 11 1919	1.62	1.08	.76	.59	.47	.39	.20
Apr. 23 1920	1.92	1.23	.84	.675	.54	.46	
June 12-13 1920	1.26	.78	.58	.48	.40	.33	.27
June 17 1920	1.26	.93	.66	.51	.44	.39	.22
June 24 1920	2.40	1.74	1.34	1.08	.88	.75	.45
June 29 1920			Defective Record				
July 2-3 1920	2.34	1.44	1.06	.85+	.71	.61	.44
July 14 1920	1.26	.66	.44	.35	.28	.23	
July 15 1920	1.26	.66					
July 24 1920	2.52	1.50	1.14	.94+	.78	.74	.46
Aug. 7 1920	2.88	1.83	1.38	1.11	.91	.79	
Aug.10-11 1920	1.38	.99	.82	.70+	.60	.52	.42+
Aug. 16 1920			Defective Record				
Sep. 10 1920	1.44	1.05	.84	.81	.71	.63	.32
Sep. 28 1920	1.56	.81	.54	.40+	.35	.30	

* From New York Station, U. S. Weather Bureau.

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TABLE 5

Maximum Storms—Stapleton and Borough Hall Gages, Richmond

MAXIMUM STORMS 1914 to 1920 incl.
STAPLETON AND BOROUGH HALL GAGES - RICHMOND

RATE OF RAINFALL IN INCHES PER HOUR

DUR. IN MIN.	5	10	15	20	30	40	50	60	80	100	120
May 11 1914	1.92	1.92	1.92	1.92							
Aug. 11 1914	5.4	2.06	2.0	1.5	1.0	1.0					
Aug. 21 1914	2.0	2.0	2.0	1.8	1.6	1.35					
May 22 1915	3.6	3.5									
June 30 1915	1.8	1.8	1.8	1.8	1.4	1.2	1.2	1.5	1.09	1.02	
July 5 1915	3.65	3.65	2.8	2.4	1.84						
July 13 1916	4.3	4.29	4.29	4.29	3.20	2.7	2.3	2.0			
June 14 1917	2.28	2.23	2.23	2.23	2.23	2.23	2.23	2.1	2.0	1.92	1.76
July 12 1917	3.28	3.28	3.28	2.58							
Aug. 30 1917	3.3	3.3									
May 21 1918	4.73	4.02	2.88	2.34	1.92	1.65	1.34				
July 30-31 1918	1.60	1.60	1.60	1.60	1.60	1.60	1.52	1.35	1.11	0.98	0.88
July 19 1919	1.80	1.8	1.76	1.41	1.00	0.80	0.65	0.56	0.45	0.39	0.35
July 3 1920	4.28	3.90	3.60	3.18	2.62	2.15	1.81	1.55	1.21	1.07	0.97
July 24 1920	4.28	4.20	3.20	2.70	2.60	1.68	1.62	1.50			
Aug. 17 1920	2.66	2.66	2.66	2.66	2.42	1.85	1.48	1.28	0.98		

TABLE 6

Maximum Storms—Tottenville Gage, Richmond

MAXIMUM STORMS 1910 to 1920 incl.
TOTTENVILLE GAGE - RICHMOND

RATE OF RAINFALL IN INCHES PER HOUR

DUR. IN MIN.	5	10	15	20	30	40	50	60	80	100	120
Oct. 20 1910	1.95	1.95	1.95	1.95	1.95	1.82	1.56	1.46	1.38	1.12	1.08
July 17 1911	1.26	1.26	1.26	1.26	1.26	1.26	1.14	1.02	0.79		
" 21 1911	1.73	1.73	1.73	1.73	1.60						
May 29 1912	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.18	0.90	0.90	
Aug. 19 1912	2.84	2.84	2.84	2.25	1.60	1.25					
Aug. 21 1912	2.20	2.20	2.20	2.20	2.20	1.80					
Oct. 23 1912	1.98	1.98	1.76	1.35	1.06	0.95	0.88	0.75	0.60	0.50	0.42
July 24 1913	1.76	1.76	1.76	1.56	1.48	1.20	1.02	0.90	0.90		
Sept.30											
Oct. 1 1913	5.20	5.20	5.20	5.20	4.02	1.77	1.56	1.40	1.25	1.12	1.00
Oct. 25 1913	1.43	1.43	1.43	1.43	1.32	1.14	1.00	0.85	0.72		
June 10 1914	1.80	1.20	1.20	1.11	1.00						
May 22 1915	2.40	2.40	2.40	1.80	1.24	0.93	0.76	0.64	0.52	0.45	0.38
Aug. 4 1915	2.40	2.40	2.40	2.19	2.04	1.96	1.74	1.50	1.25	1.20	1.10
July 22 1916	3.39	3.39	3.39	3.39							
" 26 1916	1.45	1.45	1.45	1.45	1.45	1.45	1.45				
Sept.15 1916	2.04	2.04	2.04	2.04							
Apr. 21 1917	4.44	2.70	2.16	1.65	1.14	0.88	0.72	0.62			
June 14 1917	2.76	1.80	1.60	1.60	1.26	1.00	0.90	0.77	0.63	0.54	
July 14 1917	2.30	2.30	2.30	2.30	2.30	1.64	1.46				
Oct. 23 1917	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.62	0.59	0.54
May 21 1918	2.40	2.40	2.40	2.40	1.72	1.38	1.18	1.04	0.84	0.70	0.60
June 5 1918	2.58	2.58	2.58	2.19	1.50						
" 20 1919	3.60	3.60	3.60	2.70	1.84	1.40	1.18	1.00	0.80		
July 6 1919	3.54	3.54	3.54	3.54	2.44	1.89	1.56	1.32	1.03	0.84	0.71
June 24 1920	3.00	3.00	3.00	3.00							
July 22 1920	2.90	2.90	2.90	2.90	2.40	2.10	1.82	1.74	1.55	1.46	1.36

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TABLE 7

Maximum Storms—Central Park Gage, Manhattan

(See 1913 Report of Rainfall and Run-off Committee for storms prior to 1914)

MAXIMUM STORMS OCT. 1, 1913 to Dec. 31, 1920.
CENTRAL PARK GAGE - MANHATTAN

RATE OF RAINFALL IN INCHES PER HOUR

DUR. IN MIN.	5	10	15	20	30	40	50	60	80	100	120
July 2 1914	3.00	2.52	1.71					1.01			
Aug. 21 1914	3.00	2.22	2.20	2.07	1.80						
June 15 1915	3.60	2.76	2.24	1.80							
June 30 1915	4.80	3.90	3.48	3.24	2.46						
July 5 1915	6.36	5.40	4.32	3.36	2.50						
July 26 1916	3.00	2.52	1.92	1.68							
July 27 1916	2.16	1.92	1.68	1.50	1.68						
Sept. 8 1916	3.00	2.46									
June 14 1917	2.64	2.22	2.32	1.96	1.88	1.61	1.30	1.13	1.12	1.24	1.12
July 12 1917	2.04	1.80	1.44								
July 22 1917	4.20	3.78	3.20								
May 10 1918	1.80	1.62	1.40	1.29	1.40						
May 21 1918	2.40	1.98	1.80	1.65	1.74						
June 7 1918	2.76	2.22	2.04	1.65	1.48	1.53	1.38				
July 6 1918	2.76										
July 30 1918	1.92	1.50	1.20	1.35							
June 20 1919	6.00	3.72	2.84								
July 26 1919	3.96	3.00	2.48	2.21	1.90	1.51	1.37	1.16			
Aug. 25 1919	2.88	1.50									
Sept.22,1919	2.52	1.86	1.64	1.80	1.70	1.60	1.47	1.39	1.22	1.09	1.02
June 29 1920	3.72	2.64	2.24	1.89	1.38						
July 3 1920	4.20	2.58	1.90	1.35	1.22	.96	.84	1.06			
July 12 1920	1.92	1.92	1.52	1.17	.80	.81	.79	.73			
July 24 1920	3.96	3.60	3.40	2.67	2.00	1.54	1.30	1.17			
Aug. 11 1920	3.60	2.64	1.88		1.06						
Sept.12 1920	5.16	4.26	2.96								
Oct. 16 1920	2.40	2.16	1.64	1.32	.92	.72	.51	.53			

TABLE 8

Maximum Rates of Rainfall at Different Localities in the Same Storm

MAXIMUM RATES OF RAINFALL AT DIFFERENT LOCALITIES IN THE SAME STORM.

		Manhattan		Brooklyn		Richmond
		Central Park	U.S. Weather Bureau	Brooklyn Eagle	Bureau of Sewers	Bureau of Engineering.
5 MIN.	May 29-30,1912	6.60	1.44	1.20	2.04	3.00
	July 8, 1915	6.36	3.72	4.80	....	3.65
	July 28, 1902	6.08	5.64	....	....	....
	June 20, 1919	6.00	2.04	2.88	....	2.90
10 MIN.	Sept.4-5, 1913	6.90	3.84	4.44	3.06	1.80
	July 28, 1913	5.70	2.82	1.14	1.47	6.00
	July 5, 1915	5.40	2.76	3.90	4.08	3.65
	May 29-30,1912	5.28	1.08	0.90	1.44	2.40
15 MIN.	Sept.4-5, 1913	6.40	3.44	4.32	2.80	1.20
	July 28, 1913	4.88	1.96	1.12	1.06	6.00
	July 8, 1915	4.32	2.52	2.84	....	2.80
	May 29-30,1912	4.12	0.88	0.80	1.36	1.80
30 MIN.	Sept.4-5, 1913	5.12	2.74	3.08	2.72	0.80
	July 28, 1913	3.16	1.02	0.56	0.56	3.80
	Oct. 1, 1913	2.98	3.28	2.46	2.46	2.22
	Aug. 8, 1902	2.90	....	....	1.08	....
60 MIN.	Sept.4-5, 1913	3.40	2.00	1.92	1.64	0.55
	July 28, 1902	3.02	0.88	....	....	....
	July 28, 1913	2.68	0.54	0.28	....	1.83
	Oct. 1, 1913	1.90	2.26	1.59	1.89	1.61
120 MIN.	July 8, 1901	1.38	1.00	....	....	....
	Oct. 9, 1903	1.21	1.21	....	0.69	....
	June 14, 1917	1.12	1.76	....	....	....
	Aug. 19, 1904	1.07	....	....	1.04	1.08

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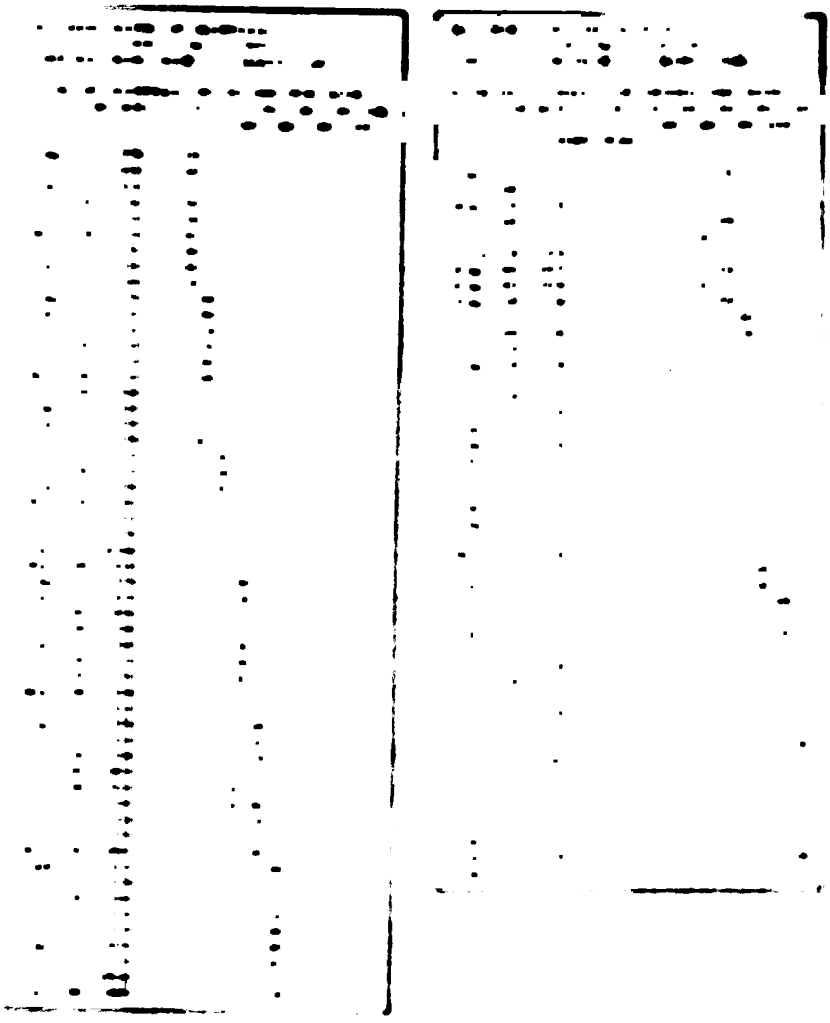

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TABLE 10

Maximum Rates of Rainfall—Gages 1, 2 and 3, Manhattan

MAXIMUM RATES OF RAINFALL
FEB. 4, 1911 to DEC. 31, 1920
GAGES 1, 2, and 3 - MANHATTAN

RATE OF RAINFALL IN INCHES PER HOUR DUR. IN MIN.		5	10	15	20	30	40	50	60	80	100	120
Oct. 1	1913	6.60										
Oct. 8	1917	5.88										
June 17	1916	5.40										
Aug. 21	1914	5.16										
Aug. 14	1915	4.80										
June 20	1919	4.80										
Oct. 1	1913		5.10									
Aug. 21	1914		4.80									
June 17	1916		4.50									
July 24	1913		4.20									
June 20	1919		4.20									
June 12	1911		3.60									
Oct. 1	1913			4.08								
Aug. 21	1914			3.48								
June 17	1916			3.40								
June 20	1919			3.28								
July 24	1913			3.16								
Aug. 15	1911			3.00								
Oct. 1	1913				3.48							
Aug. 15	1911				2.85							
Aug. 21	1914				2.85							
June 17	1916				2.64							
June 20	1919				2.58							
June 26	1919				2.55							
Oct. 1	1913					2.90						
July 26	1919					2.32						
Aug. 21	1914					2.24						
Aug. 15	1911					2.22						
June 30	1915					1.90						
July 28	1913					1.84						
Oct. 1	1913						2.48					
July 26	1919						1.97					
Aug. 21	1914						1.74					
Aug. 15	1911						1.71					
July 28	1913						1.64					
June 30	1915						1.59					
Oct. 1	1913							2.15				
July 26	1919							1.86				
July 28	1913							1.58				
Aug. 21	1914							1.43				
Aug. 15	1911							1.38				
June 30	1915							1.33				
Oct. 1	1913								1.85			
July 26	1919								1.60			
July 28	1913								1.39			
July 24	1913								1.32			
Aug. 21	1914								1.22			
June 17	1916								1.19			
Oct. 1	1913									1.52		
July 26	1919									1.23		
Sep. 23	1919									1.14		
July 28	1913									1.13		
July 24	1913									1.10		
Aug. 4	1915									1.10		
Oct. 1	1913										1.31	
Sep. 23	1919										1.10	
Aug. 4	1915										1.00	
June 26	1919										0.99	
July 28	1913										0.91	
July 24	1913										0.89	
Oct. 1	1913											1.17
Sep. 23	1919											1.01
Aug. 4	1915											0.98
July 26	1919											0.84
July 2	1914											0.71
Oct. 23	1912											0.67

TABLE 11

Maximum Rates of Rainfall—United States Weather Bureau Gage, near the Battery, Manhattan

MAXIMUM RATES OF RAINFALL
1896 to 1920 incl.
U. S. WEATHER BUREAU GAGE - BATTERY

RATE OF RAINFALL IN INCHES PER HOUR DUR. IN MIN.		5	10	15	30	60	120
July	1906	6.88					
August	1906	6.24					
August	1912	6.00					
June 24	1920	6.00					
July 22	1917	5.88					
August	1901	5.76					
July	1908	5.64					
July	1912	5.28					
Oct.1-2	1913	5.28					
July	1906		7.86				
August	1906		5.82				
July 22	1917		5.76				
August	1901		4.92				
July 5	1913		4.68				
July	1912		4.62				
Oct.1-2	1913		4.62				
July	1902		4.38				
June 24	1920		3.96				
July	1906			6.52			
August	1906			4.88			
July 22	1917			4.48			
Oct.1-2	1913			4.20			
July	1912			4.00			
July 5	1913			4.00			
June 14	1917			3.88			
Sep.4-5	1913			3.44			
Aug. 15	1919			3.36			
July	1906				4.18		
June 14	1917				3.34		
Oct.1-2	1913				3.28		
July 22	1917				3.20		
July	1912				2.94		
Sep.4-5	1913				2.74		
August	1906				2.70		
August	1904				2.36		
July	1908				2.28		
July	1906					2.30	
Oct.1-2	1913					2.26	
Sep.4-5	1913					2.00	
June 14	1917					2.00	
July	1912					1.74	
October	1912					1.70	
August	1904					1.66	
July 22	1917					1.65	
June	1900					1.55	
June 14	1917						1.75
Oct.1-2	1913						1.67
Sep.4-5	1913						1.41
July	1906						1.28
October	1903						1.21
October	1912						1.13
June	1903						.97
July	1912						.93
August	1904						.90

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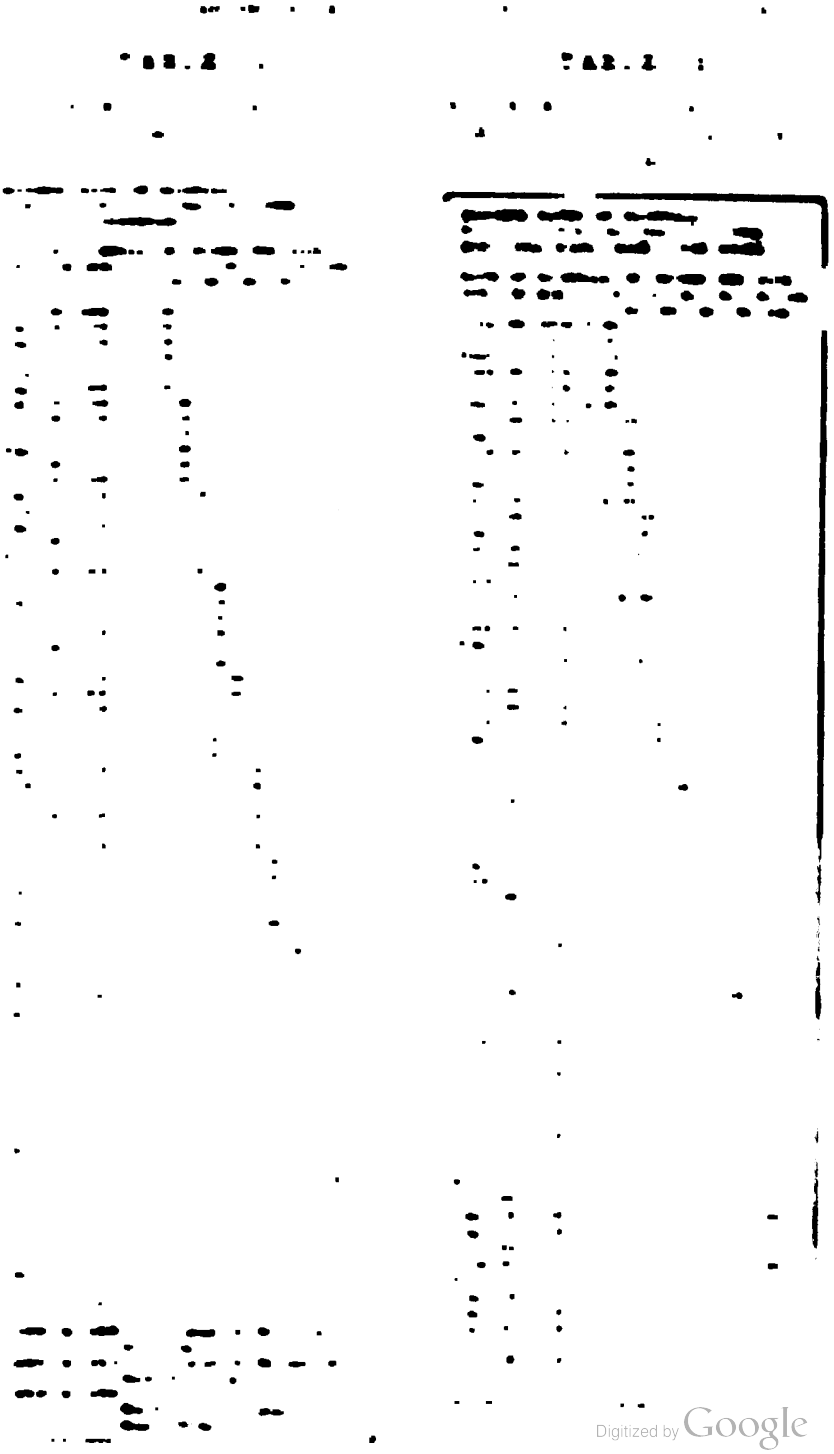
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TABLE 14

Maximum Rates of Rainfall—Stapleton and Borough Hall Gages, Richmond

MAXIMUM RATES OF RAINFALL
1903 to 1920 incl.
STAPLETON & BOROUGH HALL GAGES - RICHMOND.

DUR.	RATE OF RAINFALL IN INCHES PER HOUR IN MIN.	5	10	15	20	30	40	50	60	80	100	120
Oct. 1 1913	6.36											
Aug. 13 1909	6.00											
Aug. 11 1914	5.35											
Aug. 10 1904	5.28											
July 30 1905	5.04											
July 8 1907	4.80											
Oct. 1 1913		5.64										
Aug. 13 1909		5.28										
July 30 1905		5.00										
Aug. 10 1904		4.86										
July 8 1913		4.44										
July 13 1916		4.29										
Oct. 1 1913			5.36									
July 30 1905			4.80									
Aug. 10 1904			4.40									
Aug. 13 1909			4.40									
July 13 1916			4.29									
Sep. 16 1903			4.00									
Oct. 1 1913				5.04								
July 30 1905				4.35								
July 13 1916				4.29								
Aug. 10 1904				3.93								
Sep. 16 1903				3.93								
Aug. 13 1909				3.72								
Oct. 1 1913					4.74							
Sep. 16 1903					3.50							
July 30 1905					3.30							
July 13 1916					3.20							
Aug. 10 1904					2.96							
Aug. 13 1909					2.90							
Oct. 1 1913						4.94						
Sep. 16 1903						2.85						
July 13 1916						2.70						
July 30 1905						2.55						
Aug. 1 1913						2.40						
Aug. 13 1909						2.27						
Oct. 1 1913							4.72					
Sep. 16 1903							2.56					
July 13 1916							2.30					
June 14 1917							2.23					
July 30 1905							2.05					
Aug. 1 1913							2.04					
Oct. 1 1913								4.39				
Sep. 16 1903								2.44				
June 14 1917								2.10				
July 13 1916								2.00				
Aug. 1 1913								1.88				
July 30 1905								1.77				
Oct. 1 1913									3.90			
Sep. 6 1903									2.03			
June 14 1917									2.00			
Oct. 23 1912									1.74			
Aug. 1 1913									1.50			
Aug. 13 1909									1.47			
Oct. 1 1913										3.43		
June 14 1917										1.92		
Sep. 16 1903										1.70		
Oct. 23 1912										1.45		
Aug. 13 1909										1.25		
June 29 1903										1.20		
Oct. 1 1913											3.10	
June 14 1917											1.76	
Sep. 16 1903											1.50	
Oct. 23 1912											1.25	
June 29 1903											1.11	
Aug. 13 1909											1.11	

TABLE 15

Maximum Rates of Rainfall—Tottenville Gage, Richmond

MAXIMUM RATES OF RAINFALL
1913 to 1920 incl.
TOTTENVILLE GAGE - RICHMOND

DUR.	RATE OF RAINFALL IN INCHES PER HOUR IN MIN.	5	10	15	20	30	40	50	60	80	100	120
Sep.30 1913	5.20											
Apr.21 1917	4.44											
Jun.20 1919	3.60											
July 6 1919	3.54											
Sep.30 1913		5.20										
Jun.20 1919		3.60										
July 6 1919		3.54										
" 22 1916		3.39										
Sep.30 1913			5.20									
Jun.20 1919			3.60									
July 6 1919			3.54									
" 22 1916			3.39									
Sep.30 1913				5.20								
July 6 1919				3.54								
" 22 1916				3.39								
Jun.24 1920				3.00								
Sep.30 1913					4.02							
July 6 1919					2.44							
" 22 1920					2.40							
" 14 1917					2.30							
" 22 1920						2.10						
Aug. 4 1915						1.96						
July 6 1919						1.89						
Oct.20 1910						1.82						
July 22 1920							1.82					
Aug. 4 1915							1.74					
Oct.20 1910) Sep.30 1913)							1.56					
July 6 1919)												
" 22 1920								1.74				
Aug. 4 1915								1.50				
Oct.20 1910								1.46				
Sep.30 1913								1.40				
July 22 1920									1.58			
Oct.20 1910									1.38			
Aug. 4 1915) Sep.30 1913)									1.25			
July 22 1920										1.46		
Aug. 4 1915										1.20		
Oct.20 1910) Sep.30 1913)											1.12	
July 22 1920												1.36
Aug. 4 1915												1.10
Oct.20 1910												1.08
Sep.30 1913												1.00

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GEORGE F. MARTIN, Estimate and Apportionment, Manhattan.
HARRY R. SPANGENBERGER, Docks, Manhattan.
HARRY KOVNAT, Water Supply, Gas and Electricity, Manhattan.

FOR ASSOCIATE MEMBER

ALEXANDER SCHRIER, Water Supply, Gas and Electricity, Manhat.
EMIL A. VERPILLOT, Education, Manhattan.
BENJAMIN KURTZ, Education, Manhattan,

and they were elected to membership, subject to confirmation by the Society.

The following members were dropped for non-payment of dues: Charles H. Bull, Robert H. M. Canfield, Harry L. Coyne, Dennis J. Grillo, Louis M. Hackenberg, Emil J. Hundt, James P. B. Hyndman, James McKenna, Alfred I. Ostrander, John H. Petty and Bernard A. Ruge.

President Powell stated that a circular letter directing attention to the advantages of membership in the Society had been recently sent to all non-members in the municipal employ. The Board concurred in the suggestion of the President to have a follow-up circular prepared.

The question of taking steps to secure greater publicity for engineers and the work performed by them in the municipality was presented for consideration.

MEETING OF THE SOCIETY, February 24, 1922.—President Charles U. Powell presided; 100 members and guests were present.

The minutes of the meeting of January 25, 1922, were read and approved.

The Society confirmed the election by the Board of Directors of 14 members and 3 associate members.

The Secretary presented a resolution adopted by the Board of Directors as follows:

"That the President be empowered to appoint a Committee consisting of Messrs. Farley, Ferris and Barney, the President and the Secretary of the Society for the purpose of investigating the merits of a bill now pending before the Legislature providing for the mutual transfer of employees between the City and State departments in those cases where the employees are paid entirely out of City funds, with the understanding that if the Committee is favorably impressed with the proposed bill that a communication be

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sent to the Governor and to the members of the Legislature endorsing it on behalf of the Society.

"In case the Society concurs in this action, the Committee is to be authorized to address a communication to the Governor and to members of the Legislature endorsing the bill."

The resolution of the Board of Directors was approved by the Society.*

The address of the evening entitled "Some Impressions From a Recent Six Weeks' European Trip" was presented informally by Robert Ridgway, M.M.E.N.Y., Chief Engineer of the Transit Commission. The address was devoted principally to personal experiences and impressions of post-war conditions in several of the principal European cities and furnished an unusually interesting evening.

The meeting then adjourned and refreshments were served.

BOARD OF DIRECTORS, March 22, 1922.—President Charles U. Powell presided. There were also present Messrs. Bell, Barney, Endemann, Turner, Brush, Farley, Thomas, Ferris, Raisman, Dobbin, Borst, Koch, Tidd, Levy, Libby, Cherry, Lonergan and Moon.

The minutes of the meeting of February 24, 1922, were read and approved.

The Finance Committee's report submitting vouchers aggregating $253.02 was accepted and the bills ordered paid.

The Membership Committee reported favorably on the following applications:

FOR MEMBER

FRANCISCO LEVY, Plant and Structures, Manhattan.
ADRIAN LAFORGE, Plant and Structures, Manhattan.
RHEINHOLD H. F. HALSEY, Education, Manhattan.
RICHARD M. SUTHERLAND, Topographical Bureau, Queens.

FOR ASSOCIATE MEMBER

FRANCIS K. HYDE, Topographical Bureau, Queens,

and also on the reinstatement of CHARLES J. MCGRONAN as Member, and they were elected to membership, subject to confirmation by the Society.

* See First Quarterly Issue of the MUNICIPAL ENGINEERS JOURNAL, page 14, for the communication to the Governor.

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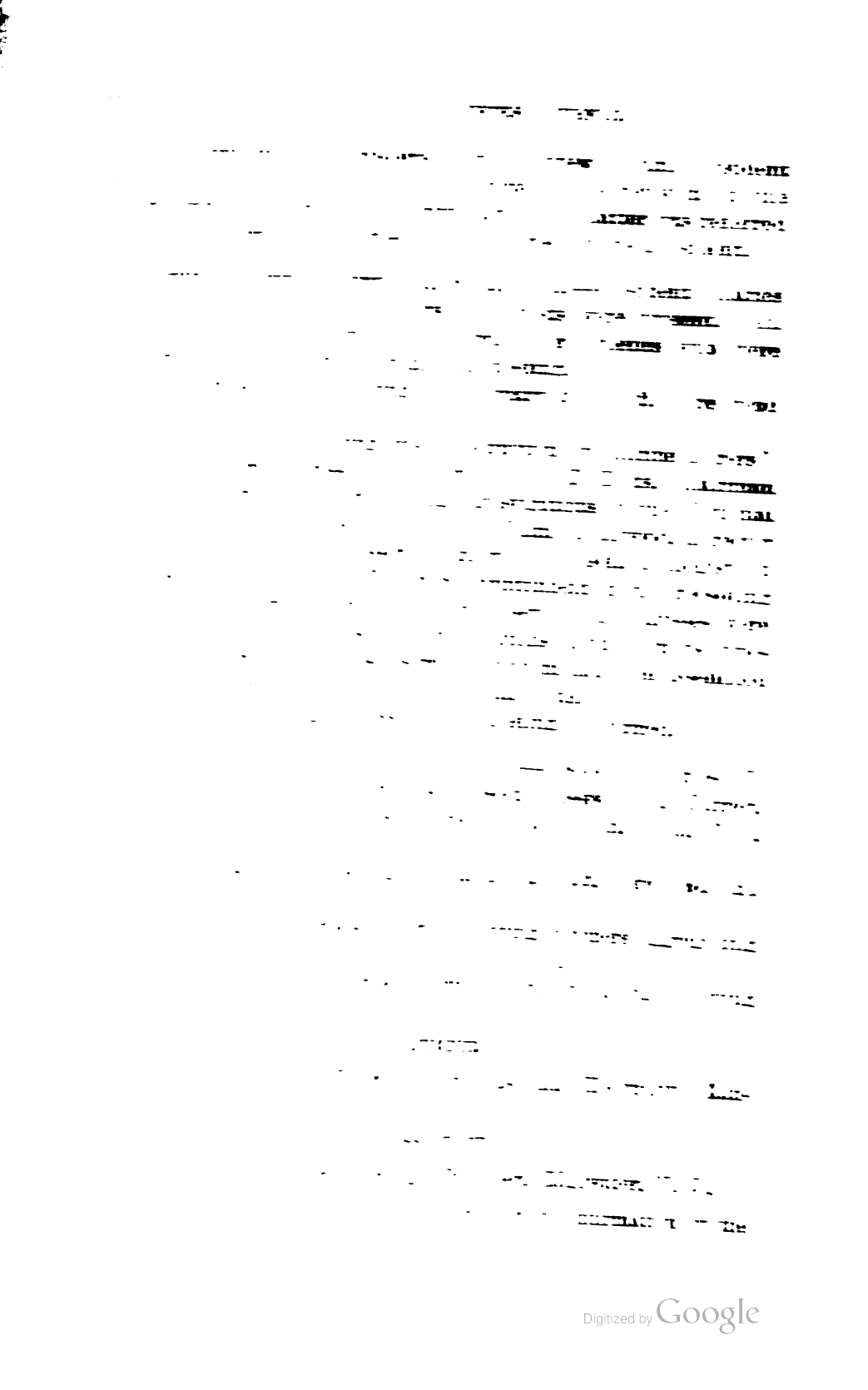

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Board of Water Supply since 1918, has been appointed to fill the vacancy. Mr. Smith has been retained on the consulting staff of the Board.

Borings have been started for the exploratory work connected with the Brooklyn-Richmond Freight and Passenger Tunnel which is to be built under the Narrows of New York harbor by the Board of Estimate and Apportionment. ARTHUR S. TUTTLE is Chief Engineer of the Board of Estimate and Apportionment and JESSE B. SNOW is Chief Engineer of the Tunnel Division which will be in active charge of the construction of the tunnel.

In addition to the exceptionally large school building program already under way, the Board of Education has now under consideration an additional program numbering 42 items, the estimated cost of which is $29,990,660. Of this amount $14,813,660 is for elementary schools and portables and $15,177,000 is for high schools. In order to carry out this plan it is proposed to take on about 50 additional draftsmen, thus increasing the force from about 200 to 250.

AARON I. RAISMAN, Division Engineer of the Transit Commission, was tendered a send-off luncheon by the engineers of that Commission on April 12, prior to starting on a 2-months' trip to Europe.

Borough President Julius Miller of Manhattan has started an investigation of the proposition to relieve the north and south vehicular traffic in that borough by widening the roadways of Park avenue from the Grand Central station north. It is proposed to accomplish this by reducing the width of the park strips in the center of that avenue.

William J. Fitzgerald, paving contractor, has finished the laying of a section of experimental pavement in Second avenue, Manhattan, from 4th to 5th streets. Untreated white-oak wood blocks laid on a mastic cushion form the wearing surface. The usual 6-inch concrete foundation was used.

The construction of the coffer-dam for the sewage-treatment plant at West and Canal streets, Manhattan, is now in progress. The upper stage of the excavation has been made, the bracing placed and the work of driving the steel sheet piling is under way. Orders are being placed by the contractor, the Riverdale Construction Com-

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pany, for the various parts of the mechanical equipment, consisting of pumps, motors, screens and electrical plumbing, heating and ventilating equipment. Treatment is to be made by fine screens of the Rex Band type, the equipment consisting of three screens composed of bronze plates 6 feet by 18 inches by 3/16 inch, perforated with 2-inch by 3/64-inch slots and having a capacity of 21 cubic feet per second.

The Borough President of Manhattan has actively taken up the proposition of physically linking up the northerly ends of Seventh and Eighth avenues with the Speedway, by means of a street along the westerly shore of the Harlem river. If this improvement is carried out, it will provide a low-level thoroughfare between the Harlem Flats and the Dyckman Street district. Such a highway would be exceptionally valuable to heavy traffic, as the climb over the hilly section of Washington Heights would be thus avoided.

The Manhattan Borough President's Office recently submitted to the Board of Estimate and Apportionment a change in the city map proposing the laying out of a large extension to Inwood Hill park at the northerly end of the borough. The new park will connect up the existing Inwood Hill park with Isham park, including in the area embraced one of the most picturesque localities in the entire city.

Borough President Miller is now conducting preliminary negotiations with the New York Central Railroad Company for the improvement of traffic conditions on Park avenue between 45th and 46th streets. It is proposed to open up a new roadway around the southerly and easterly sides of the Grand Central Terminal building, passing over 45th street and thence down into Park avenue at 46th street. This roadway will carry north-bound traffic only. The existing high-level roadway around the westerly side of the Terminal building will be partially reconstructed and a similar connection with Park avenue at 46th street will provide for south-bound traffic.

The Borough President of Manhattan is preparing plans for continuing the paving of the marginal streets along the East River and Hudson River water-fronts. A marked improvement is brought about, both in appearance and utility, by crowning the pavement for the full width of the streets rather than using the old inverted pyramid method of drainage.

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HENRY S. KANSKI, Leveler, Office of the President of the Borough of The Bronx, was retired from active service under the provisions of the New York City Employees' Retirement System by the Board of Estimate and Apportionment on April 1. Mr. Kanski was in all probability the oldest employee in the City employ so far as active service is concerned, having entered the employ of the City early in 1861 and being actively engaged to the date of his retirement. Between 1861 and 1912 he was employed in various capacities in the old Department of Charities and Correction, Department of Public Parks, Manhattan, Department of Public Works, Manhattan, Department of Water Supply, Gas and Electricity and the Department of Parks, Bronx. Since 1912 he was employed in the office of the President of the Borough of The Bronx.

Mr. Kanski was born on November 26, 1841, and on the date of his retirement was as hale, hearty and active as most men twenty years his junior. His retirement was fittingly observed by his fellow employees who also later commemorated the event by presenting him with a set of engrossed resolutions signed by the Borough President and entire staff and all of the employees in the Engineering Bureau in the Office of the Borough President.

WARREN R. BORST, Assistant Engineer in the Sewer Bureau of the Borough of Richmond, has obtained a patent for a new method of activating sludge to be used in connection with the activated-sludge method of sewage disposal and an experimental plant is about to be constructed at Red Bank, N. J. Mr. Borst was in charge of the extensive sewage-treatment experiments which have recently been carried on in the Borough of Richmond.

CORNELIUS V. V. POWERS, Division Engineer, Transit Commission, died at his home June 18, as the result of a shock he sustained earlier in the week. Mr. Powers had been associated with the city subway construction continuously since 1900 and for 15 years prior to that time was in the engineering department of the New York Aqueduct Commission. He had served as director and was First Vice-President of the Society during 1921.

NEW YORK-NEW JERSEY VEHICULAR TUNNEL

The contract for the New York-New Jersey Vehicular tunnel under the Hudson river was signed March 30, 1922, and the work promptly started. The amount of the bid is $19,331,723.50, the

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Courtesy of The General Contractors Association.

SIGNING THE CONTRACT FOR THE HUDSON RIVER VEHICULAR TUNNEL.

ding, left to right: J. P. DOLAN, Secretary, New Jersey Commission; CLIFFORD M. HOLLAND, Chief Engineer
ss. WINDELS, Counsel, New York Commission; W. A. FLINN, EDWARD M. [illegible] M. FROHLICH
RGARY, New York Commission.
E: THEODORE BOETTGER, Chairman, New Jersey Commission; GEORGE R. DYER, Chairman, New York Com
sion: GEORGE H. FLINN.

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largest single construction contract ever awarded in either state. The bond required is $4,000,000. Booth & Flinn, Ltd., are the contractors and Clifford M. Holland is Chief Engineer of the Bi-State commission that is in charge of the work. The contract time is 36 months. The tunnel, which will be of twin tubes, is approximately 1½ miles long between the shafts and will require 116,000 tons of cast-iron and cast-steel tunnel lining, 5,000 tons of bolts and rods and 228,000 barrels of cement.

THE PROFESSIONAL ENGINEERS LICENSE LAW

The doubts that have existed with relation to the date upon which the licensing of professional engineers and land surveyors becomes effective appear to have been removed by a careful reading of the amendatory bill which was signed by the Governor of the State on May 5, 1921.

It seems that, instead of passing detached amendments as is customary, the entire law was re-enacted, thereby advancing all of its provisions to May 5, 1923. It is believed desirable, however, to obtain licenses without delay and evidence is at hand to show that their possession is of material value in court proceedings.

THE MANHATTAN BRIDGE

The roadway facilities of the Manhattan bridge are soon to be increased by converting the space formerly occupied by surface-car tracks, now abandoned, on the easterly upper deck into a roadway for vehicular traffic. A clear width of 23 feet 6 inches will be made available, thereby increasing the total roadway width by 67 per cent. and, by separating the slow and fast moving vehicles, the carrying capacity will be increased by more than that percentage. The length of the bridge from Canal street, Manhattan, to Nassau street, Brooklyn, is 6,855 feet. The improvement was opened for traffic on June 15. The work was planned and directed by Grover A. Whalen, Commissioner of the Department of Plant and Structures, and Edward A. Byrne, M.M.E.N.Y., Chief Engineer of that department.

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Hudson River water-front. I take pleasure in turning the meeting over to him as Chairman of the National Committee and will ask him to conduct it and to introduce the other speakers. I take pleasure in introducing Mr. Betts.

R. T. BETTS.*—The Committee on Marine Piling Investigations of the National Research Council expresses its thanks and appreciation to the Municipal Engineers who have made this meeting possible and to the other societies who have so heartily responded to our invitation to participate, the Society of Terminal Engineers having cancelled its March meeting to emphasize its interest in this subject.

From earliest engineering times harbor engineers have been more or less acquainted with the destructive attacks of the humble "ship-worm" and other marine borers. With respect to the coasts of the United States, in general, it has been known that the colder waters of the North Atlantic are less infected with marine pests than those of the South Atlantic and the Gulf, and that they have been more or less abundant in Pacific waters from California to Alaska. It has also been known that borers of the Teredo type enter and riddle the interior of timbers and that those of the Limnoria type attack and destroy the surface. Some carry on their depredations between the mud line and approximately low water, while others appear to operate between tidal planes. Further, it has generally been supposed that these destructive borers could not exist in waters of low salinity or in waters highly polluted with sewage or manufacturing wastes, so that, in harbors about large cities, especially those in northern waters, the harbor engineer has felt secure in supporting his marine structures on untreated timber.

Consequently, when in 1919 and 1920 the destruction wrought by these borers in San Francisco bay, estimated at from $15,000,000 to $20,000,000, became known, there was some alarm and anxiety on the part of engineers over their possible appearance in other harbors, and when this same destructive species was discovered last summer in Barnegat bay, about fifty miles from New York, it seemed prudent to recognize the fact that what had happened in San Francisco bay might happen in New York harbor.

In response to an appeal, the National Research Council appointed a committee consisting of the speaker as Chairman, Mr.

* Chief Engineer, Robbins-Ripley Company, New York City.

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George J. Ray, Chief Engineer of the Delaware, Lackawanna & Western railroad, as Vice Chairman, Dr. Hermann von Schrenk, Consulting Timber Engineer of the New York Central and New York, New Haven and Hartford railroads and other interests, Dr. C. A. Kofoid, Professor of Zoology at the University of California and a member of the San Francisco Bay Committee, Mr. George M. Hunt, United States Forest Service, and Dr. Albert L. Barrows, Biologist, Assistant Secretary of the National Research Council, Washington, D. C., as Acting Secretary. This Committee has appointed Colonel William G. Atwood, Director.

It is proposed to make a comprehensive investigation of the coastal waters of the United States and contiguous shores, and to form reciprocal relations through the international connections of the National Research Council with similar investigators in Europe for the purpose of ascertaining more definitely the propagation and habits of these pests, the probability of their occurrence, the means to be taken to protect existing structures and economical designs for new structures.

It is proposed to carry on these investigations through local port committees under the general direction and advice of the National Committee. Already the San Francisco Committee has become affiliated with the National Committee as its port committee in San Francisco. Other committees are in the making at Seattle and on the Gulf, and it is expected that committees will be formed at other Atlantic and Pacific ports. Here in New York a committee has been formed comprising many well-known engineers, biologists and chemists, with Mr. Ernest P. Goodrich as Chairman. This committee has had a preliminary meeting and plans for the investigations at New York have been started.

The investigations will follow, in general, the methods which have been found successful at San Francisco, and will be organized along the following lines:

Hydrographic.—Which will cover climatic conditions, temperatures, salinity and sewage observations.

Biological.—Which will cover present distribution, history, dissemination, growth, habits, factors influencing rate of attack, etc., of these marine borers.

Engineering.—Which is intended to cover design, construction, maintenance and repair, with relative costs of marine structures attacked or subject to attack.

With this brief statement of the plans of the National Committee and the New York Port Committee we will begin our program with

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an address by Colonel William G. Atwood, Director of the National Committee. Colonel Atwood was for five years in charge of the construction of the Alaska Central railroad, where Teredo problems were encountered. Later he was Chief Engineer of the Lake Erie and Western railroad. During the war he was Colonel of Engineers with the American Expeditionary Force, American Transportation Representative with the Supreme Economic Council of Paris in 1919, and Technical Advisor of the Kingdom of the Serbs, Croats and Slovenes.

COLONEL WILLIAM G. ATWOOD.*—The address which Mr. Betts referred to will, as indicated in the program, simply be the reading of a paper written by Dr. Hermann von Schrenk who, unfortunately, is unable to be present. Many of us consider Dr. von Schrenk the leading timber expert in this country, and he is well-known abroad. In order to save time, the speaker will make no comments other than the reading of Dr. von Schrenk's paper.

(Colonel Atwood then read Dr. von Schrenk's paper.)

HERMANN VON SCHRENK, PH. D.†—The subject of this discussion is marine borers as they are commonly called, and their relation to marine structures.

The term "marine borer" has been applied to a group of animals which in the course of their life history bore holes into the submerged portion of wood in salt or brackish water. Their activities have been recorded from early Roman times. With increasing shipbuilding, particularly on the west coast of Europe, the destruction caused by various forms of marine borers to ships and wharves was increasingly noted. The literature beginning with the sixteenth century is full of references to the destructive action of these marine organisms. While they have probably been continuously active, every now and then unusually severe outbreaks occurred which focussed public attention, and which gave rise to much discussion on the part of scientific men and engineers, as evidenced by the voluminous literature dealing with these periods.

The common European ship-worm, for instance, is reported as having been unusually severe in the following periods: 1730-1732, 1770, 1827, 1858-1859, when it attacked the dikes of Holland during periods of reduced rainfall.

* Director, Committee on Marine Piling Investigations, National Research Council, New York City.

† Consulting Timber Engineer, New York Central and New York, New Haven and Hartford railroads.

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Marine borers belong to two groups, the Mollusca and the Crustacea. The Mollusca family, more familiar in the form of oysters and clams, is represented by the Teredo, and the Crustacea, of which better known species are lobsters, crabs, etc., by the Limnoria, Sphaeroma and others.

Several Varieties of Ship-worms and Other Marine Borers.

The first group, the Teredo and Xylotria, bore the wood, forming long tunnels separated only by very thin partitions. The second group perform their destructive work by chewing the wood and forming more or less shallow burrows near the surface of the wood, resulting in the characteristic hour-glass appearance. So far as is known, neither of these groups use the wood to any extent as food. The purpose of their boring seems to be only to obtain shelter. There is a possibility, however, that some of them do make some use of the wood as food and this is one of the points to be further investigated.

Of the Mollusca forms of marine borers, the Teredo and Xylotria are the leaders from the standpoint of destructiveness. They are

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long worm-like creatures with soft bodies living in the burrows which they have excavated, with the head toward the interior and the so-called tail protruding from the hole through which entry was made. The body of the worm secretes a thin limelike shell with which the walls of the tunnel are lined. The typical appearance of these worms after being removed from their tunnels can be observed by an inspection of the several specimens which are shown in the exhibit in the Entrance Hall of the Engineering Societies Building, 29 West 39th street, New York City.

Section of a Pile Destroyed by Teredo Navalis, one of Several Marine Borers.

The shells of these animals which form the boring apparatus are on the head. They operate by two powerful muscles for opening and closing them. The edges of these shells are provided with minute file-like teeth by means of which the creature rasps the wood and bores the tunnel.

As previously stated, the body of the animal is soft and extends through the entire length of the burrow to the opening through which it entered the timber.

The tail end of the animal has two organs, the palates and the siphons. The more prominent are the palates, feather-shaped segmented structures attached to the side of the body by stalks. Each palate is convex outward and concave on the inner face and the two when brought together form a cone with the point outward. When disturbed, the animal can bring these two palates together and when in this position the opening in the timber is effectually closed, thus keeping out intruders and harmful material.

The siphons are two muscular tubes, one longer than the other, which extend out between the palates, activated by cilia within the body. A current of water passes into the body through the longer siphon and out through the shorter one. The siphons are plainly

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fresh water. This interferes with their normal physiological processes and after a time death ensues. * * * The lowest levels of salinity at which Teredo Navalis will survive in piling appear to lie between 7.5 and 10 parts per thousand. The levels at which the larval stages will attack piling probably lie somewhere above this, perhaps between 10 and 15 parts per thousand. * * * The limits of salinity within which the different species of Teredo thrive vary greatly. The borer Nausitoria Dunlopi lives in the River Como in India in fresh water. The Teredo Navalis, on the other hand, is a species adapted to live in brackish water, while the ship-worm, Teredo Megotara lives in timbers on the high seas. The Xylotria Setacae on our coasts lives in maximum salinities and has not been found to thrive in waters below 20 parts per thousand. From the foregoing it will appear that the different marine borers have different degrees of tolerance for waters with high and low salinities, and it seems probable that each will thrive best under salinities of a rather different degree." From an observation of the range of salinity in the Carquinez straits of San Francisco bay in 1920 it is noted that the Teredo survived the periods of low salinity probably due to the fact that these periods were comparatively short, and did a great amount of damage in the following summer and autumn.

As a comparison with local conditions it can be said that salinities as high as 9 parts per 1,000 have been found in the Hudson river at Tarrytown, but it is improbable that this period of high salinity is long enough to permit the development of the Teredo Navalis.

Temperature has a less important bearing on the distribution of these organisms. Again quoting Dr. Kofoid: "The marine borers as a whole have such a cosmopolitan distribution from the equator almost to the Arctic Circle and such a wide range of adaptedness that the temperature changes in adjacent localities have very little influence over their distribution. They do, however, set limits to the occurrence of particular species. In common with other animals the borers cannot live without oxygen. Waters in which the oxygen quantity is too low to support life will, of course, be free from these organisms. Temporary sewage pollution can be tided over by them provided sufficient oxygenated water is subsequently supplied. By closing the palates they can rest for a certain period but not indefinitely. High sewage pollution, therefore, may frequently result in making water unfit for their life processes and thereby render a harbor immune; however, recent developments in San

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of the San Francisco Bay Marine Piling Committee of the American Wood Preservers Association. These reports are of extreme technical value and are especially interesting on account of the recent appearance of this same organism in New York. The sudden collapse of piers brought the problem home to the San Francisco communities and the same thing may happen in New York. Preventive measures were of course immediately sought and a study was made of the methods of creosoting, the use of concrete and other measures. Full details with reference to these measures will be found in the reports referred to. Suffice it to say that the San Francisco Bay Marine Piling Committee calls attention (1) to the fact that the appearance of these borers should be regarded as an extremely serious matter by all concerned, the rapidity with which they work and the rapidity with which they spread being some of the startling findings of the Committee; (2) that good creosoting may be regarded as an effective protective measure, but that in the use of creosoted material precautions should be taken to see that good work is done, effective penetration secured, good oil used, and above all, that creosoted material is handled without injury. Other protective devices experimented with consist of concrete placed around untreated piles and sheathings of various kinds. A concrete protection can be worthless if not carried below the mud line which is the lower limit of action of the borers. The same result will be obtained if the concrete shell is broken.

The specific contribution which the San Francisco Bay Marine Piling Committee has made to date is the prompt realization that the proper basis for handling the Teredo problem required detailed and persistent research with reference to the fundamental conditions necessary for a proper understanding of the whole question. They started immediate determinations on the salinity, temperatures and oxygen content of the waters affected, and a biological station was at once established to study the enormous and complex problems connected with the life history of the organisms involved. Studies of tidal currents, food supply and allied questions were assigned to properly equipped investigators and an excellent start has been made toward securing the necessary data upon which preventive measures must in the long run be based. This brings us naturally to the situation on the Atlantic and Gulf coasts and specifically in New York harbor. The question uppermost in the minds of those interested in marine works protection is, will the San Francisco Bay experience be duplicated here and at other points on the Atlantic and Gulf coasts? The finding of the same destructive organism at

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Barnegat bay has already been referred to. Unfortunately no one can say either yes or no in answer to the question: "Will they appear in New York?" One is warranted, however, in saying that in view of the fact that they are so close to the harbor there is a chance that they will, and immediate steps should be taken to obtain data upon which to base intelligent future action. Enough has been said in the foregoing to call attention to the vital relation which exists between living conditions and the activities of the Teredo and other marine borers.

For years we have believed that the high sewage pollution of the waters of the New York district has rendered Teredo attacks more or less problematical. It is, therefore, rather disquieting to be advised that the organism which is at work in San Francisco bay appears with just as much vigor near the mouths of large sewers as it does elsewhere; in other words, that this particular form appears to thrive in waters with high sewage contamination. We may, therefore, not be as safe in New York from an invasion of this organism as we thought. Believing that a proper understanding of this entire question is essential, this meeting has been called to advise you of the present status, and to take counsel as to what should be done in the future. It appears to be obvious that immediate data as to temperatures, salinities, oxygen content, tidal currents, etc., should be taken at definitely selected points in the waters tributary to New York harbor and that concurrently therewith a definite biological survey should be made of these waters by competent men to determine food conditions and actual distribution of marine organisms in the water at the present time.

Dr. Kofoid in the first report of the San Francisco Bay Marine Piling Committee issued in 1921 calls attention to what are called biological indicators, stating: "There are, however, certain forms of marine life easily identified and quickly recognized and of very cosmopolitan distribution in most of the harbors of the world which must be used as indicators of suitable conditions for the occurrence of the marine borers, etc." The biological survey just spoken of would make such necessary preliminary determinations. In view of the enormous financial investments in unprotected wooden structures in New York harbor the need for speedy, carefully executed scientific investigation of the fundamental conditions of the life and activities of these marine borers would appear obvious and concerted action should be taken at once. The past summer the advice given by one of the leading engineers of the Pacific coast to those on the Atlantic was: "If this organism or one like it should ever

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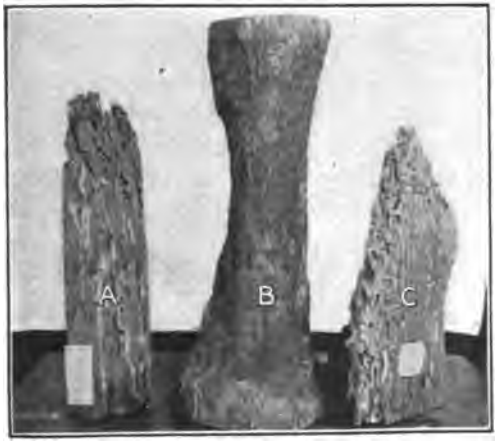
appear within reasonable proximity of one of your eastern harbors, start to work at once. I cannot make this advice too strong because from our experience in San Francisco bay, the faster you act, the better it will be in the long run."

I have attempted in the foregoing in a more or less desultory manner to touch some of the high spots. Other speakers will dwell on phases in this immediate district. I would leave with you, however, this thought, that we are dealing with creatures of tremendous destructive powers that work unseen and with extraordinary speed. If conditions in this harbor are such that they cannot exist, heroic measures may be necessary. If, on the other hand, conditions are unfavorable, we may have nothing to fear. It behooves us, however, to start at once to organize in such a way that necessary data may be quickly obtained. To do this the biologist, the chemist and the engineer must join hands and use all available agencies to the end that we may track these enemies of our marine structures to their lair.



A—Fragment of Southern pine pile cut between medium and low tide; three years service; Biloxi, Miss. B—Limnoria action; untreated pile; two years service; Boca Grande, Fla. C—Teredo and Limnoria action; specimen secured March, 1922, at Manhattan Beach, N. Y.

MR. BETTS.—The next speaker will be Professor Thurlow C. Nelson, of the State Experiment Station and State Board of Shell Fisheries of New Jersey and Biologist at Rutgers College, who made the recent discovery of Teredo in Barnegat bay.

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PROFESSOR THURLOW C. NELSON.*—In the year 1888, the State of New Jersey established an oyster-culture laboratory on the Atlantic coast and here work has been carried on practically continuously up to the present time. My own identification with this experiment station came in 1908, and during the succeeding years I have seen nothing like what happened this last summer; it seems worth while to report my observations to you. It may be of interest to know that the life history of the oyster and the clam and of these marine borers is similar, and owing to that fact we are continually getting information about the life history of these marine borers during our oyster investigations, and since we have during this entire period from 1888 a fairly complete series of density and temperature readings for the coastal waters of the State of New Jersey, we have here something of a background to go by.

In connection with our experiments, we had sunk a cypress platform covered with oyster shells to obtain an oyster "set" in Barnegat bay on July 3, 1921, about 2½ miles below the Pennsylvania Railroad bridge at Barnegat pier. On August 15 the platform collapsed owing to a very heavy invasion of Teredo Navalis. The borers, which average about 3/5 inch at this time, were so closely crowded together that little further growth could have occurred. As high as eighty of the molluscs were found in a cubic inch of the wood. In spite of their small size and short growth period they were sexually mature and contained larvae ready for extrusion. This illustrates well the great rapidity with which Teredo Navalis multiplies, since the attachment and growth to maturity occurred in less than the six weeks time during which the platform was overboard.

The temperature and salinity records of water samples taken beside the platform during the entire period show that the average salinity was 10155, ranging from 10090 to 10170. The average temperature was 78 degrees Fahrenheit, with a maximum of 87 and a minimum of 70 degrees. The salinity was at all times far above that at which Teredo Navalis will grow and reproduce.

Photomicrographs were shown comparing the native ship-worm, Bankia (Xylotria) Fimbriata, with Teredo Navalis and illustrating larvae taken from the gills of Teredo and also those free-swimming in the water.

A chart was shown giving figures for the salinity variations in a depth of 6 feet in Barnegat bay. On one occasion with a salinity of 10095 at the surface, the water on the bottom 6 feet below had a salinity of 10170. The relation of such density variations from

* Biologist, Rutgers College, New Brunswick, N. J.

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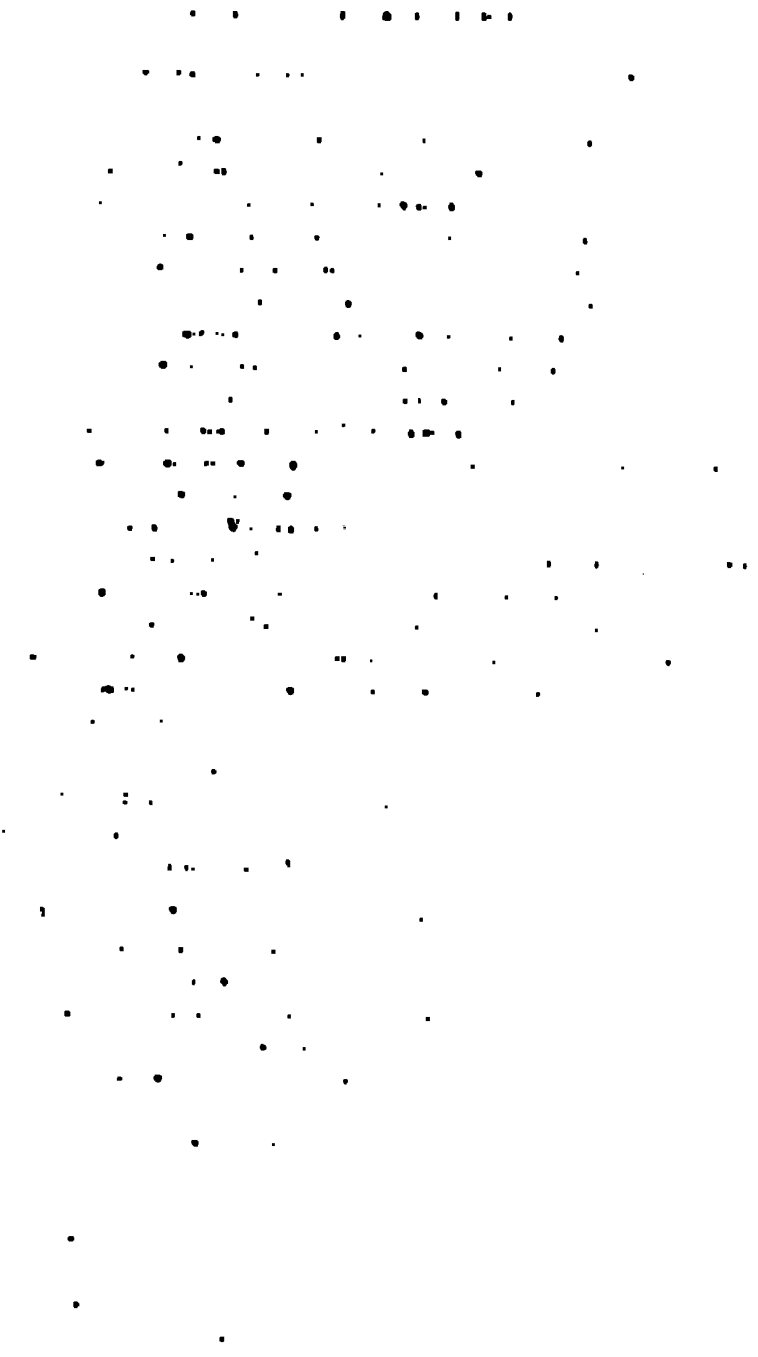

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Piling that we pulled from the draw-bridge of the Reading railroad at Atlantic City showed clearly the action of the Limnoria and in the renewal of that structure we used nothing but heavily creosoted piling.

Pier 18, the Central Railroad coal-dump pier opposite Ellis Island, costing several millions, is on heavily treated piling. The risk is too great to think of supporting it on untreated piling and every stick of piling that supports that concrete structure, even above high-water mark, is creosoted as thoroughly as we know how, mostly with 24 pounds per cubic foot.

We are all the time on the lookout for better protection of foundations, wherever we have to contend with salt water. One was found some time ago, originally built in concrete, that had to be protected with a creosoted crib to keep the old foundation intact. That same scheme has been used on some of our concrete piers where our road crosses small streams along the Jersey coast.

The fact that things did happen in San Francisco bay at points where it was not supposed to happen, led me to superimpose the outline of New York harbor on the map of San Francisco harbor, which gives us some idea as to what might happen if the same conditions of rainfall should take place here in New York, or if any of the other conditions that happened in San Francisco should be duplicated in New York. The damage which occurred in San Francisco bay in relatively about where the Harlem river enters the North river, and where it was never expected.

MR. BETTS.—This concludes the announced program. We feel that it is a very important subject, that these marine borers are worthy to be classified as one of the forces of nature with which the engineer has to contend and about which he should have as much authoritative information as possible.

The Committee will constantly keep in mind that the practical results from its investigations are needed by the engineers and the executives of the owners of water-front property. While the studies along scientific lines will be pursued to the limit, their results will be co-ordinated from time to time so as to give the engineer information which he can use for the safer or more economical construction and maintenance of water-front structures.

It is a pleasure to be able to present at this time Mr. Ernest P. Goodrich, a consulting engineer of experience in harbor construction, well known to many of you, who has accepted the chairmanship of the New York Port Committee.

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ERNEST P. GOODRICH,* M.M.E.N.Y.—I have been much instructed by the discussion of what has been happening to our structures throughout the country around the seacoast. The sudden appearance of this pest made us think first, perhaps, that it was caused by the war,—so many things are blamed on that,—that possibly it might have been another incidental result. Possibly it is, in an indirect way, due to the war,—in some way traceable, perhaps, to the wooden ships which were built and went around the world and brought back some of these things from the other side. That will be another reason, perhaps, for abandoning the wooden ship program.

In any event it is a question which must be investigated. It is primarily an economic one. The estimates of fifteen to twenty million dollars damage in San Francisco bay indicate at least to some extent what might happen in New York. Those of us who have been designing such structures have had the possibility in mind. The Bush docks, for example, built some twenty years ago, were deliberately designed with the majority of the cross-section a solid fill, so that any attack which might be made would be confined to the outer platforms. It is very interesting to be told that investigation of the wooden piling which is untreated at the Bush terminal has thus far disclosed no indication of attack by any marine borers. With their coming into Barnegat bay, with the known trend of the Gulf stream, with ships coming and going, and with the possibilities of the larvæ which perhaps will be discharged three times a year, swimming a mile or two, you can see that there may be a progressive action which may carry it as far north as sewage, salinity or temperature, or whatever the factors are, will permit.

The New York Port Committee, to which Mr. Betts has referred, has only begun to get started. It was appointed by the National Committee only within the past week. It has held one preliminary meeting at which sub-committees were arranged and a program of procedure is now being formulated.

The engineering features are the ones which are important to all of us. They are the ones which involve the economics of the subject and naturally we must know something of its life to be able to combat the losses which are caused by this monster. That is where the biologist comes in. The chemist comes in on the side of prevention (creosoting possibly), but whatever it is, the question

* Chairman, New York Port Committee, National Research Council, New York City.

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of the best chemical has to be carefully determined. Perhaps some new chemical must be discovered. Going back to the war,—men were discovering so many things during that period that doubtless we can discover something that will prevent the continuance of this destructive agent in the future, if we go at it with might and main, as those who are interested in the subject intend to do.

MR. BETTS.—The Committee will be glad to hear from any one in the audience who has any remarks to make on this subject.

ALFRED D. FLINN,* M.M.E.N.Y.—In explanation of the part of the National Research Council in this investigation, a few words may be in order. This Council was organized in 1916 by the National Academy of Sciences with the co-operation of the associations of scientists and technologists of our country. It has thirteen divisions, six of which deal with general relations and seven with science and technology. Among the seven are two divisions which are particularly concerned in our program—the Division of Engineering and the Division of Biology and Agriculture. These two divisions are co-operating in directing this research into the activities of marine borers of all species—not merely the Teredos—which are found upon the coasts of the United States and its nearby islands, including the Panama Canal zone. The National Committee would go further, also, and look into the causes of deterioration of the various substitutes for wood in marine structures, such as concrete and metals. The Engineering Foundation is co-operating.

It is almost exactly one year since the committee on the Pacific coast brought to the attention of the Washington office of the Research Council the problems arising in San Francisco bay and asked the Research Council to give them attention. The San Francisco Committee turned to this Council because it is a national organization and can bring to bear upon the problem the aid of scientists and technologists in all the lines necessary when attacking so complex and important a project. The project has been carefully considered.

Someone has suggested that the figures for the damage at San Francisco were "newspaper figures". The $15,000,000 estimate was conservatively made by the engineers directly interested in the properties. Recently, one corporation alone among the sufferers has been advertising bonds to the amount of $2,000,000 to replace one of the structures.

* Chairman, Division of Engineering, National Research Council, New York City.

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In any event great care should be used against floating piles in water, before driving, where the Teredo exist.

PHILIP AYLETT.*—It was my intention to call attention to a somewhat different phase of this question. I shall not have very much to say about the Teredo Navalis, nor about New York harbor, further than to quote a portion of a letter which I have received from a man who can speak authoritatively. I took up, over the telephone, this matter of pile protection and the status of pile preservation in New York harbor, with Mr. K. Peabody, who is Superintendent of Terminals, Buildings and Structures for the New York Central railroad. As these structures cover the entire harbor, more or less, from one end to the other, you may look upon this letter as giving you the present general status of pile preservation in New York harbor. This is a part of Mr. Peabody's letter, which I will read:

> "Referring to your telephone conversation of yesterday relating to damage to piles in New York harbor by Teredo, about fifteen years ago I was very much interested in this subject and made a careful search in so far as it was possible for me to do, for indications of ravages of this sort. I found one specimen of a pile taken from the East river near Port Morris where the pile had been damaged to a considerable extent, but since that time I have only seen a few piles that were enough damaged to materially impair their strength. We do, however, frequently find piles that have been bored, possibly by some species of the Limnoria. * * * In fact, marks of this kind are common, but usually the holes are small and not very numerous."

The great problem as I see it is not keeping the Teredo away from the pile, but keeping the pile away from the Teredo. You bring all these great monstrous timbers, this beautiful banquet, and set them down right in front of this glutton, invite him to his feast, and then by biological and engineering and chemical means you try to poison him when he goes at it. Substitute something that he cannot digest, like reinforced concrete, then you have your problem solved; and the quicker engineers get together and get at it, the better. It will only be a few years when they will have to get at it.

FRANCIS T. O'KEEFE.†—It may be interesting to know what the City of New York is and has been doing on the preservation of wooden piling and the substitution of concrete therefor. The Dock

* Assistant Engineer, New York Central railroad, New York City.
† Assistant Engineer, Department of Docks, New York City.

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Department has made, for the past four years, a periodical inspection of wooden piling and timber in various parts of the harbor, and collated the entire result. We find on the North and East rivers, immunity from either the Teredo or the Limnoria. We found recently at Sheepshead bay the most complete instance of destruction of piles by the Limnoria that has ever come under our observation or under that of those who have gone into the subject. We have preserved some remarkable specimens of this destruction.

In Jamaica bay, where we have found the Limnoria to some extent, we have substituted concrete sheet piling and piles for wooden piles, but in Manhattan, especially on the North and East rivers, in all our new structures we find that the wooden piling below low water was practically indestructible. We have had divers' examinations extending over, I think, twelve years, and to-day the piers in the Chelsea section and the old piers in the Gansevoort section stand unimpaired below low water.

We tore out recently what I think—and I think Mr. Betts will agree—was the oldest wooden structure in the harbor, at Piers 1 and 2. While we have no record when the bulkhead on Piers 1 and 2 was built, we believe it was around 1857 or 1858, and we took out of that bulkhead, at a foot above low water, white pine logs 20 inches in diameter of hewed timber, practically as good as the day they were placed in the work. We have preserved some of them.

I want to make known that the City has been alive to the problems of the period and has been up to date in substituting, as former speakers have advocated, concrete where possible for piling.

Dr. David T. Day.*—I just wanted to call your attention to the fact that creosote may not necessarily be the only material which we will have available for attacking this problem, although the material to which I am going to refer has not been available in any considerable quantity at all until the present time.

I have found in some work on the oil shales of the United States, that we have as much, in some oils, as six per cent of pyridine bases. It would not be a bad estimate, and probably rather a conservative one, to state that you can get at least one per cent. of pyridine bases, on the average, from the oils contained in the shales obtained from Colorado, Utah or from any of the Eastern states. The shales in Pacific Coast states do not yield so much.

* Petroleum Expert, Washington, D. C.

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Comparative tests as to the fungicidal value of pyridine have shown that pyridine is perhaps a little better. That may be taken as a sufficiently encouraging indication of their possible value in this connection, to justify further study. It is not necessary to go to Colorado to get pyridine for experimental work in connection with the work of the Research Council. You can get plenty of "bone-oil". This bone-oil, obtained in making animal charcoal, is interesting for this research work. Pyridine is something of which you can find a plentiful supply. You can be reasonably sure that there will be more on the market in the next year or two than could possibly be used for creosoting timbers, including creosoting piling.

MR. POWELL.—We are certainly indebted to the National Research Council for this entertaining and instructive meeting, and on behalf of the Municipal Engineers I wish to extend our thanks to them.

In view of this menace, New York City cannot rest easily and assume that its substantial immunity during the past fifty years will continue. We must take precautions to ascertain the first symptoms of the presence of the wood borer in our harbor, and we must have organized in advance the procedure upon attack. To accomplish this will require extended scientific investigations into biological, chemical and engineering fields.

On behalf of the Borough of Queens of the City of New York, the speaker recently investigated the effects of the Teredo upon the structures along the Atlantic coast as far south as Key West, and was amply convinced of the importance of immediate action by the City to safeguard its present structures and to provide against this creature in our contemplated mammoth dock and bulkhead improvements.

The City of New York should take immediate action, either through co-operation with the New York Committee of the National Research Council in the form of a contribution toward its support, or through its own departmental employees, to keep a vigilant watch upon all existing structures, not, as at present, annually, but daily, and steps should be taken to compile detailed data with reference to temperature, salinity, degree of pollution and all the other factors which enter into the life history of the marine borer, commonly known as the ship-worm.

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MEETING OF THE SOCIETY, May 24, 1922.—President Charles U. Powell presided; 70 members and guests were present.

The minutes of the meeting of April 26, 1922, were read and approved.

The Society confirmed the election by the Board of Directors of new members.

Amos Schaeffer, M.M.E.N.Y., Consulting Engineer, Office of the President of the Borough of Manhattan, then addressed the Society on "The Conservation of Existing Facilities for the Relief of Traffic Congestion". After an interesting and extended discussion the meeting adjourned and refreshments were served.

BOARD OF DIRECTORS, September 26, 1922.—First Vice-President Clarence F. Bell presided. There were also present Messrs. Barney, Endemann, Farley, Riedel, Attwater, Thomas, Ferris, Raisman, Dobbin, Koch, Tidd, Levy, Libby, Cherry, Lonergan and Moon.

The minutes of the meeting of May 24, 1922, were read and approved.

The Finance Committee's report, submitting vouchers aggregating $977.29, was accepted and the bills ordered paid.

The Membership Committee reported favorably on the following applications:

AS MEMBER

PETER J. CAHILL, Topographical Draftsman, Engineering Bureau, The Bronx,

IRVING CANNON, Architectural Draftsman, Board of Education,

JOHN DELANEY, Assistant Engineer, Bureau of Buildings, Queens,

JOHN M. FARIES, Engineer-Inspector, Bureau of Buildings, The Bronx,

JOSEPH P. FOLEY, Inspector, Department of Public Works, The Bronx,

HYMAN HORNESTAY, Junior Engineer, Transit Commission,

EVAN L. GUNTER, Architectural Draftsman, Board of Education,

BERNARD MARCUS, Topographical Draftsman, Department of Public Works, Manhattan,

RUDOLPH P. SMITH, Architectural Draftsman, Board of Education,

JOHN C. SUCHMINSKI, Topographical Draftsman, Department of Public Works, Manhattan,

HENRY J. ULMER, Architectural Draftsman, Board of Education.

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AS ASSOCIATE MEMBER

GEORGE E. GRIFFITHS, Rodman, Board of Water Supply,
MICHAEL WHITE, Axeman, Topographical Bureau, Queens,

and they were elected to membership, subject to confirmation by the Society.

MEETING OF THE SOCIETY, September 27, 1922.—First Vice-President Clarence F. Bell presided; 90 members and guests were present.

The minutes of the meeting of May 24, 1922, were read and approved.

The Society confirmed the election by the Board of Directors of new members.

Acting President Bell announced that Commissioner Grover A. Whalen, of the Department of Plant and Structures, who was to have given the address on "The Activities of Department of Plant and Structures" for the evening, had been unexpectedly called out of town, and that an address would be delivered by Deputy Commissioner William W. Mills of that department. Mr. Mills entertained the Society in an interesting manner and answered numerous questions regarding the work of the department. At the close of the discussion he was tendered a rising vote of thanks.

The Prize Committee appointed to judge the most meritorious paper presented during the year 1921, reported through its Chairman, Amos Schaeffer, that they had awarded the prize to John C. Riedel, M.M.E.N.Y., for his paper entitled "The Design and Construction of an Important System of Sewers in Brooklyn Known as the Ralph Avenue Sewer System".

The meeting then adjourned and refreshments were served.

BOARD OF DIRECTORS, October 25, 1922.—President Charles U. Powell presided. There were also present Messrs. Bell, Barney, Brush, Riedel, Thomas, Wood, Raisman, Borst, Koch, Tidd, Levy, Libby, Cherry, Lonergan and Moon.

The minutes of the meeting of September 26, 1922, were read and approved.

The Finance Committee's report, submitting vouchers aggregating $254.19, was accepted and the bills ordered paid.

The Membership Committee reported favorably on the following applications:

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AS MEMBER

MELCHIORRE MORASCA, Architectural Draftsman, Transit Commission,

FRANK DOUGLAS MOTT, Junior Engineer, Transit Commission,

JOHN HOWARD TOMLINSON, Assistant Engineer, Bureau of Buildings, Manhattan,

and they were elected subject to confirmation by the Society.

MEETING OF THE SOCIETY, October 25, 1922.—President Charles U. Powell presided; 110 members and guests were present.

The minutes of the meeting of September 27, 1922, were read and approved.

The Society confirmed the election by the Board of Directors of new members.

Joseph Haag, Secretary of the Board of Estimate and Apportionment, one of the speakers for the evening, on "Two Years' Operation of the New York City Employees' Retirement System", sent his regrets at being unable to be present, due to pressure of work, and the subject was continued by Ralph Van Name and George G. Buck. Following these addresses the speakers answered a large number of questions regarding the specific application of the Pension Law, and a vote of thanks was tendered them for their interesting and instructive handling of the subject.

It was moved and seconded that the President be requested to appoint a committee of three members of the Society to be designated as the Pension Committee, but as it was pointed out that any desired information could be readily obtained from representatives of the Pension System, the motion was lost.

The Prize for the most meritorious paper during the year 1921 was presented to John C. Riedel, M.M.E.N.Y., for his paper entitled "The Design and Construction of an Important System of Sewers in Brooklyn Known as the Ralph Avenue Sewer System." Mr. Riedel expressed his thanks and appreciation of the honor.

The meeting then adjourned.

PERSONALS AND NOTES

S. F. FERGUSON has withdrawn from the firm of Nicholas S. Hill, Jr., and S. F. Ferguson, Consulting Engineers, 112 East 19th street, New York City, and the practice of the firm will be carried on by NICHOLAS S. HILL, JR., at the same address.

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HENRY PROPPER has accepted the position of Engineer with the Tampico Navigation Company of Tampico, Mexico, and is now stationed at that city.

BENJAMIN W. RONZONE, assistant engineer in the Office of the Borough President of The Bronx, has only recently returned to duty after a protracted period of illness following an attack of appendicitis, with a subsequent operation.

JOHN H. WEINBERGER visited old friends in the Municipal Building recently. Mr. Weinberger was at one time Engineer of Highways in the Borough of Queens and more recently Engineer of Sewer Design in the Office of the President of the Borough of Manhattan. He is now a prosperous fruit raiser in Zionsville, Pa., but continues to take a keen interest in his former associates and their work.

FREDERICK W. KOOP, assistant engineer in the office of the Chief Engineer of the Board of Estimate and Apportionment, died suddenly of heart disease on August 14, 1922, following an operation at the Battle Creek Sanitorium where he was undergoing treatment. Mr. Koop was connected with various City departments since 1898, always in an engineering capacity. He is survived by a wife and one son.

The first completed section of the Coney Island Board Walk was formally opened on October 28, 1922, by Borough President Edward Riegelman of Brooklyn, eleven months after the contract was signed. The section was about 1,000 feet long.

Bids for the Brooklyn shaft of the Narrows tunnel, extending from Brooklyn to Staten Island, were opened by the Board of Estimate and Apportionment on November 24. The contract was subsequently awarded to Patrick McGovern, Inc., and the order has been given to commence work. This marks the beginning of construction on this very important project and of what is believed to be the longest sub-aqueous tunnel yet undertaken.

Driving of the New York and New Jersey Vehicular tunnel was started in September when the first push was given the shield on the Manhattan side of the river.

PETER KRULDER, rodman in the Department of Public Works of the Borough of Manhattan, died October 1, 1922, after a brief illness.

Jamaica Bay boulevard, in the Borough of Queens, will be one of the finest scenic drives in the world,—five miles in length across

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Jamaica bay partly on a viaduct and partly over a fill. It will shorten the distance between Manhattan or Brooklyn and the Rockaways by 10 miles. It is estimated to cost about $3,500,000 and will be paid for entirely by the City at large. There was no expense for title, the City owning all the land and the land under water, except at the two ends where the owners not only ceded but agreed to do the grading. It is estimated that it will be opened for traffic in a little over a year. Work on the boulevard was started October 29, 1921, the contract having been awarded to Smith, Hauser & MacIsaac. This firm encountered difficulties from the start, and were obliged to stop driving piles at the Rockaway Beach end last spring both on account of the character of the ground and also because of inadequate equipment. The piles are all of pre-cast reinforced concrete and some of them are the largest ever cast, being 94 feet in length and 2 feet square. In September the contract was taken over by Patrick McGovern, Inc., and the work is now progressing actively.

Several large street-opening proceedings in the Borough of Queens have been authorized by the Board of Estimate and Apportionment this year, among which are Merrick boulevard and Northern boulevard. Two others now before that Board are Liberty avenue and Rockaway boulevard. All are widenings of existing thoroughfares and are badly needed for the relief of traffic, especially in the first two cases where bad traffic congestion occurs on Sundays and holidays. The combined mileage affected is about 15 miles.

The tunnel excavation for the 8-foot by 8-foot 3-inch tunnel sewer in East 26th street, Manhattan, between Madison avenue and the East river, was completed early in October. The contractor, Patrick McGovern, Inc., is now placing the concrete lining. A pneumatic system for delivery of concrete to the forms is being used and concrete is being successfully delivered at distances of 700 and 800 feet from the charging apparatus. The rates of progress for placing the lining have been maintained as follows: 200 linear feet of invert per day; 200 feet of side-walls per day or 50 linear feet of roof arch.

The regulating and grading of Pinehurst avenue, Manhattan, from West 183rd street to West 187th street has been completed. This is one of the new streets in upper Manhattan through property formerly part of the old James Gordon Bennett Estate.

Contract No. 1 of the Carmine street and Sixth avenue (Manhattan) sewer improvement is well under way. This work includes a storm sewer over the Seventh Avenue subway at Carmine street and a sanitary sewer siphon under the subway at the same location.

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The rubble concrete retaining-wall along the east side of Laurel Hill terrace, Manhattan, from West 181st street to West 183rd street, abutting High Bridge park, has been completed and the curbs and sidewalks are being laid.

A contract was recently awarded for the construction of sidewalks in the ends of the park strips at Park avenue, Manhattan, from 57th street to 69th street. These new sidewalk strips will provide safety platforms at the north and south sides of all intersections, the crossing of Park avenue being extremely dangerous for pedestrians under the old conditions.

MEMOIRS

IGNACIO MAREA DE VARONA*

Died May 12, 1922

Ignacio Marea de Varona, son of Ignacio M. and Angela M. (de Aguero) de Varona, was born at Puerte Principe, Island of Cuba, February 4, 1842. His ancestors were members of prominent Spanish families in Cuba. He received private instruction preparatory to his entering Mr. Berger's French School, Madison avenue, New York, where he was prepared for the Rensselaer Polytechnic Institute, Troy, N. Y., which he entered in September, 1860, and graduated therefrom with the degree of C.E. in 1863.

Mr. de Varona began his professional work immediately upon graduation and continued the practice of his profession throughout his long life. The earlier part of his professional career was spent in Cuba, South America, Europe and the United States, on railroad work. In 1882 he was appointed as assistant engineer on the Brooklyn water-supply work, and continued in connection with the City's water-supply system until his retirement on July 1, 1914. In 1902 he was appointed Chief Engineer in charge of the Brooklyn system, and in 1905 was appointed Chief Engineer, having jurisdiction over all the boroughs of Greater New York. From 1906 to 1910, Brooklyn, and for a time some of the other boroughs, were under a separate engineering organization, but upon the reorganization of the department in 1910 Mr. de Varona was again placed in charge of the entire City water-supply.

Mr. de Varona was a man of great mental ability, with an unusual amount of physical and nervous energy. He strongly fought

* Memoir prepared by WILLIAM W. BRUSH, M.M.E.N.Y., Deputy Chief Engineer, Department of Water Supply, Gas and Electricity, New York City.

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for what he thought represented the best interests of the City, and he carried through to successful completion many important improvements to the system, among which were the development of the gallery system on Long Island, the high-pressure fire-service systems in Brooklyn and in Manhattan, and the remodeling of the distribution system in Brooklyn.

Mr. de Varona died on May 12, 1922, at his home, 805 St. Nicholas avenue, New York, and he is survived by several sons and daughters.

PETER KRULDER*

Died October 1, 1922

Peter Krulder, Rodman with the Department of Public Works of the Borough of Manhattan, was born at Alpine, N. J., on March 12, 1877, of Holland Dutch parents, but early in his boyhood he moved to New York City where he attended the East 67th Street public school. In 1905 he was married to Sophie Wittenberg of Mount Vernon, N. Y. His service with the City of New York began in 1906 as axeman in the Office of the President of the Borough of Richmond.

When the United States entered the World War he joined the 102nd Engineers and he had never severed his connection with the army. An attack of pneumonia complicated by a liver affliction caused his death on October 1, 1922, after an illness of only one day. Interment was made in the family plot at Woodlawn cemetery. Mr. Krulder joined the Society in 1915 and was accustomed to attend the meetings with regularity.

AWARD FOR PRIZE PAPER FOR 1921

The Prize Committee, appointed to judge the most meritorious paper in promoting engineering knowledge presented during the year 1921, has awarded the prize to John C. Riedel, M.M.E.N.Y., for his paper entitled "The Design and Construction of an Important System of Sewers in Brooklyn Known as the Ralph Avenue Sewer System." The paper was presented at the meeting of October 26, 1921, and was published in the Third Quarterly Issue of the JOURNAL for 1921. It was followed by an extended discussion that was continued in the First Quarterly Issue of 1922.

* Memoir prepared by JOHN S. BUTLER, M.M.E.N.Y., Inspector of Public Works, Office of President of Borough of Manhattan.

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INSPECTIONS

Coney Island Board Walk

June 24, 1922

The inspection was attended by over forty members and guests who were taken over the entire length of the walk which extends from the foot of Ocean parkway to the entrance of Sea Gate at West 37th street. It consists of a board walk 80 feet wide upon treated timber beams supported by concrete girders resting on precast reinforced-concrete piles. The pile bents are 20 feet on centers. The piles are square in cross-section, 14 inches on side, 28 and 30 feet long and are spaced 10 feet on centers in a transverse direction. The superstructure will consist of 4-inch by 14-inch creosoted yellow-pine timbers spaced two feet apart. The flooring will be of dressed lumber laid with ⅛-inch joints.

Provision will be made for two longitudinal strips 6 feet wide of closely laid planking which will be used for rolling chairs. Galvanized iron pipe railings will be placed along the ocean side of the walk and elsewhere where needed. Steps will be built to the beach at frequent intervals and lamps will be provided along the walk. To protect the walk and to increase the extent of the existing beach there will be placed by hydraulic methods 1,700,000 cubic yards of sand filling, timber groynes and stone jetties. The groynes and jetties will be sixteen in number, will extend from the existing beach oceanward and will be spaced about 600 feet apart.

The quantities, beside the sand filling, of some of the material required are approximately as follows: 4,000,000 feet, board measure, of timber, 75,000 feet of timber piles, 760,000 square feet of flooring, 40,000 linear feet of concrete girders, 4,000 reinforced-concrete piles and 110,000 tons of rock for the jetties.

The contractor, the Phoenix Construction Company, is performing the work at an estimated cost of $1,900,000. Philip P. Farley, M.M.E.N.Y., is in general charge of the work, which is being done under the supervision of the Bureau of Highways of Brooklyn, of which Jacob Schmitt is Chief Engineer and Arthur C. Forbes, Assistant Engineer in charge of the work.

The construction of a board walk at Coney Island has been considered for twenty years but was brought to a successful conclusion by Borough President Edward Riegelman, who induced the Board of Estimate and Apportionment in 1921 to authorize the work and provide the funds.

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The Hell Gate Station of the United Electric Light and Power Company

October 21, 1922

The inspection was attended by 110 members and guests. The plant is located in The Bronx on the East river at the foot of East 134th street; it occupies four City docks and will be, when in complete operation, the largest steam-driven power plant in the United States. Its ultimate capacity will be 300,000 K.W., but only one-half that amount is being generated at the present time. Turbo-generators are used, the largest being rated at 40,000 K. W. The coal-handling plant has a capacity of 250 tons per hour and takes the coal directly from ocean-going vessels.

The station was placed in operation within one year from the start of the steelwork and less than two years from the beginning of the excavation. The inspection was an extremely interesting one, and at the close of the trip a lunch was provided for the party through the courtesy of the company.

Sperry Gyroscope Company

The Inspection Committee endeavored to arrange an inspection of the Sperry Gyroscope Company's plant on Flatbush avenue, Brooklyn, but were unsuccessful as certain experiments of a secret nature were in progress for the government. The company, however, presented the Society with 100 tickets for the Marine Show, where they had a large exhibit, with the suggestion that if the members would make themselves known they would be shown special consideration.

The show was held during the week of November 6 and many members availed themselves of the opportunity. They were shown every courtesy, and the various devices, including the ship stabilizer, gyroscopic compass and powerful searchlights, were clearly explained. The exhibit was very interesting and instructive, especially for those who are prone to being seasick, for the ship stabilizer gave promise of wonderful results. It is shortly to be given a trial on a large ocean liner.

NARROWS TUNNEL—ORGANIZATION

The Chief Engineer of the Board of Estimate and Apportionment announces that, pursuant to authority given by the Board of Estimate and Apportionment, the organization originally created to

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conduct the preliminary work in connection with the design and construction of the freight and passenger tunnel across the Narrows between the Boroughs of Brooklyn and Richmond has been materially expanded as required to develop the design for the project and execute the work.

The more important positions which have been provided for at this time are as follows: *ADMINISTRATION* — ARTHUR S. TUTTLE, M., Am. Soc. C.E., M.M.E.N.Y., Chief Engineer; HERMAN H. SMITH, M., Am. Soc. C.E., M.M.E.N.Y., Deputy Chief Engineer. *Consultants*—GLEN E. BALCH, Dredging; WILSON S. KINNEAR, M., Am. Soc. C.E., Railroad and Trench Tunnel Design and Construction; FREDERICK C. NOBLE, M., Am. Soc. C.E., M.M.E.N.Y., Tunnel Design and Construction; HENRY B. SEAMAN, M., Am. Soc. C.E., Structural Design; JOHN F. SULLIVAN, M., Am. Soc. C.E., M.M.E.N.Y., Project; SILAS H. WOODARD, M., Am. Soc. C.E., Tunnel Design and Construction. *DESIGN AND CONSTRUCTION*— JESSE B. SNOW, M., Am. Soc. C.E., Tunnel Engineer; CHARLES D. DREW, M., Am. Soc. C.E., Principal Assistant Engineer; WILLIAM McK. GRIFFIN, Resident Engineer; CLARENCE K. CONARD, M., Am. Soc. C.E., Railroad Engineer; W. C. LANCASTER, Fellow Am. Institute of Electrical Engineers, Electrical Engineer; JOHN H. QUIMBY, M., Am. Soc. C.E., Designing Engineer; ROBERT C. STRACHAN, M., Am. Soc. C.E., Assistant Engineer; CHARLES J. McGRONAN, M.M.E.N.Y., Assistant Engineer; MELVIN D. CASLER, M., Am. Soc. C.E., Assistant Engineer; EDWARD M. LAW, M.M.E.N.Y., Assistant Engineer; HANS R. JACOBSEN, M., Am. Soc. C.E., Assistant Engineer; D. W. COE, M., Am. Soc. C.E., Resident Engineer; WILLIAM J. SHEA, M., Am. Soc. C.E., Assistant Engineer; FRANCIS H. PHIPPS, Assoc. M., Am. Soc. C.E., Assistant Engineer; LEON K. MERRILL, Auditor; WILLIAM M. CONANT, Statistician.

NEW FIELDS OF INFLUENCE FOR ARCHITECT AND ENGINEER

Robert D. Kohn, Vice-President of the American Institute of Architects, addressed the Society on the above subject at the November meeting in a most interesting and enlightening manner, and the following abstracts of the points that he made are well worth several readings—they furnish much food for thought:

There has always been a misunderstanding between architects and engineers as to their particular functions. In recent times this has

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joined in it. The engineering division in charge of Mr. Morris Knowles of Pittsburg, the construction division under Mr. W. G. Luce of New York, and the design division under Mr. F. L. Ackerman of New York, very soon realized what could be accomplished by a joint study of every problem at the very beginning of every procedure. In other words, during that strenuous period of war-time activity, the architect, the engineer, the construction man, the division in charge of materials and transportation, the men in charge of layouts for water-supply, gas and electricity and street layouts, all sat down together and discussed everything from available material to the nature of the soil and possible schemes of sewage disposal. The full import of every housing project was thus at least touched upon at the very outset, and each division responsible for the solution of any part of the problem was conscious of the elements of the problem faced by the others. By the middle of 1918 the whole procedure had been immensely improved by reason of this co-operation. Shortly after the armistice at a conference held in Philadelphia attended by probably a hundred of the leading engineers, architects and construction men associated with the Shipping Board Housing division, there was only one sentiment expressed as to the most marked influence of joint work in that government service. It was that each one realized the inestimable value of co-operation in the whole construction field.

There has been one exceedingly interesting outcome of this war-time work. In a measure it was responsible for the creation of what has been called the Congress of the Building Industry. This congress movement started about two years ago and now has local branches in New York, San Francisco, Portland, Boston and Philadelphia, in which the membership consists of seven or eight groups of men connected with or interested in the building industry. Generally, the groups are the engineers, architects, contractors, sub-contractors, labor, real estate and finance.

The Congress was formed to bring together all of those elements for joint discussion of their problems. It was agreed at the start that all contentious subjects like wage rates and conditions of labor on which there is always a disagreement between employer and employee should be eliminated from the discussions of the Congress. It was recognized that these topics would always be a source of disagreement, but it was felt that there are innumerable problems with which the building industry is faced which can only be solved by

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joint study of all those interested. That the principle on which the Building Congress is based is correct is evidenced by the results already attained in the establishing of an apprenticeship school for carpenters, sheet-metal workers, painters and others, and the studies of seasonal unemployment and other subjects of importance to the building industry. What has been most effective is the fact that the best results here and elsewhere are always attained when all of the elements concerned in any particular problem work them out together, rather than one group imposing its will on the rest.

In conclusion, it seems important to point out that what can be accomplished by the engineer and architect co-operating in their own field can in a still greater measure be advanced by reason of the professional men getting together to advance the causes of value to the public. The professional man is impotent in public affairs—as a rule he is in the minority. It is rare in any public service of the government to find a man of technical ability at the head of any department. Some layman is generally put in charge and he goes through the motions of directing the work, whereas the men who really know how to do it are generally in the position where they have to take orders and fight ignorance and in some cases worse. With the exception of Mr. Herbert Hoover, who, perhaps as the result of his war-time service, is now in the government service, it is hard to find another technical man who has ever held a position of importance in the Federal government service.

Almost every subject in the way of public improvement interests all of the professions. The subject of housing, which has been endlessly discussed in the last few years is not, for instance, a subject for the architect alone, nor for the engineer alone. It interests those two professions, but it also interests the physician in the matter of public health; it interests the social worker from the point of view of the family; in certain fields, the law, items of land ownership, the proposition of maintenance and community ownership and utilities, etc.

When all the professions are brought together in some joint body to act on public questions that arise—when the weakness of a single profession acting on any public matter is overcome by the weight that can be put behind any movement by joint action, then the professionally-trained men of the country will receive from the government the consideration that they should have. Then, and then alone will we begin to get into the government an adequate measure

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MACMONNIES' STATUE OF "CIVIC VIRTUE" RECENTLY ERECTED IN CITY HALL PARK.
Courtesy of "Stone".

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Retirement System they should be exempted from the provisions of the Workmen's Compensation Law, but if not members of the Pension System, they should be allowed to remain under the law referred to.

The Directors were requested to notify the Committee regarding the procedure observed in laying off employees for lack of work.

It was voted that the arrangements for the annual meeting be left to the House Committee.

The Finance Committee submitted a detailed report for the Budget for the year 1923 amounting to $4,310 and recommended its adoption. After discussion the budget was adopted as presented.

MUNICIPAL ENGINEERS BUDGET, 1923

Budget and Account Number		Item	Allowed for 1923
Secretary.....	1	Postage	$60.00
	2	Salary of Secretary	500.00
	2-A	Salary of stenographer	50.00
	2-B	Salary of lantern operator	40.00
	3	Printing, Secretary	300.00
	4	Medals and prizes	45.00
	5	Certificates and badges	25.00
	6	Treasurer's bond	10.00
	7	Telephone listing	3.00
	8	Miscellaneous	67.00
		Total	$1,100.00
Publication Committee..	9-A	Stationery and printing	5.00
	9-B	Postage, including JOURNAL	40.00
	9-C	Drawings	5.00
	9-D	Editing	200.00
	9-E	Typewriting	10.00
	9-F	Commission on advertisements	.....
	9-G	Printing JOURNAL	1,000.00
	9-H	Plates for JOURNAL	60.00
		Total	$1,320.00
House Committee..	10	Rent, Room 601	700.00
	10-A	Lecture Hall	400.00
	10-B	Miscellaneous	20.00
	11	Collations, etc.	500.00
	12	Entertainments	200.00
		Total	$1,820.00
President.....	8-A	Typewriting, etc	20.00
Treasurer....	8-B	Typewriting, etc	20.00
Finance Committee..	8-C	Typewriting, etc	10.00
Inspection Committee..	13	Inspections and printing	20.00
		Total	$70.00
		Grand Total	$4,310.00

MEETING OF THE SOCIETY, November 22, 1922.—President Charles U. Powell presided; 60 members and guests were present.

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The minutes of the meeting of October 25 were read and approved.

The Society confirmed the election by the Board of Directors of new members.

The tellers appointed to canvass the ballots on the election of the Nominating Committee reported that 37 ballots had been cast and that the following members were elected: ARTHUR W. TIDD, JEREMIAH HUNTER, JOHN C. RIEDEL, CLARENCE E. DOBBIN, HENRY W. VOGEL, JAMES R. FERRIS, EDWARD W. WOOD, JAMES A. ROCHE, WILLIAM J. DUNCAN, WILLIAM F. LAASE, FREDERICK L. GREIFFENBERG, HARRY C. LIBBY, VICTOR H. REICHELT, HARRY R. BOUTON and IRVING M. PEYSER.

Robert D. Kohn, Vice-President, American Institute of Architects, then addressed the Society on "New Fields of Influence for Architects and Engineers". His remarks were most interesting and enlightening and furnished much food for thought.* Mr. Kohn was tendered a rising vote of thanks, after which the meeting adjourned and refreshments were served.

BOARD OF DIRECTORS, December 27, 1922.—President Charles U. Powell presided. There were also present Messrs. Bell, Barney, Riedel, Thomas, Raisman, Dobbin, Tidd, Levy, Libby, Lonergan and Moon.

The minutes of the meeting of November 22 were read and approved.

The Finance Committee's report, submitting vouchers aggregating $218.02, was accepted and the bills ordered paid.

The Membership Committee reported favorably upon the following applications:

AS MEMBER

ALFRED R. SCOTT, Topographical Draftsman, Topographical Bureau, Queens,

NATHAN SIMON, Topographical Draftsman, Bureau of Highways, Queens,

AS ASSOCIATE MEMBER

LOUIS BERGMAN, Rodman, Department of Parks, Manhattan,

NATHAN D. BRODKIN, Rodman, Department of Parks, Manhattan,

AARON EDELMAN, Rodman, Department of Parks, Manhattan,

and they were elected to membership subject to confirmation by the Society.

* Mr. Kohn's address was printed practically in full in the Third Quarterly Issue of the JOURNAL for 1922.

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T. F. Keller, Chief Engineer, Department of Docks, was reinstated by the Board as a member of the Society upon his application.

Philip P. Farley, Chairman of the Publicity Committee, presented a preliminary report in the matter of securing publicity for engineers.

The Secretary was directed to send a letter of thanks to Mrs. Frederick W. Koop for engineering books donated to the Society which belonged to her late husband.

The following were dropped for non-payment of dues: Stephen L. Garvin, Joseph G. Gordon, John A. Kalb, Alexander Loewy, David A. Magnier, John O'Rourke, Charles J. Sheil, Albert H. Silsby, Alfred C. Speight, James J. Stack and Isaac Van Kleef.

MEETING OF THE SOCIETY, December 27, 1922.—President Charles U. Powell presided; 90 members and guests were present.

The minutes of the meeting of November 22 were read and approved.

The Society confirmed the election by the Board of Directors of new members.

The report of the Nominating Committee was presented, making the following nominations for officers of the Society for the coming year:

For President	CLARENCE F. BELL
For First Vice-President	PERCY C. BARNEY
For Second Vice-President	JOHN C. RIEDEL
For Secretary	VERNON S. MOON
For Treasurer	HERMAN K. ENDEMANN
For Directors for a Term of Three Years	ALBERT E. THOMAS JAMES R. FERRIS WILLIAM E. DOWNS W. L. A. ARCTANDER JOSEPH C. COLLYER

T. F. Keller, Chief Engineer of the Department of Docks, addressed the Society on "Jamaica Bay—A Modern Sea Port". Mr. Keller reviewed the general history and early efforts made to advance the Jamaica Bay project and explained the character of the development contemplated. He was followed by Deputy Commissioner of Docks Henry A. Meyer, Past-President Philip P. Farley and other engineers connected with the Jamaica Bay Improvement.

A rising vote of thanks was extended to Mr. Keller and those who so ably discussed the paper, after which the meeting adjourned and refreshments were served.

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The Portland Cement Association believe that Portland cement derived its name from the resemblance of Portland-cement concrete to a widely-used building stone from the Isle of Portland off the coast of England, and not from the place of its origin as is generally supposed.

The twenty-fifth anniversary of "Greater New York" will be celebrated from May 26 to June 23, 1923, according to the present plans. The ceremonies will be held under the auspices of The City and will consist of parades, naval reviews, exhibitions and social functions. An elaborate program is being prepared, the details of which will be announced in the near future.

The Marine Division of the New York Fire Department was instituted in 1874 and the first fire-boat was placed in service in April, 1875. It was named the William F. Havemeyer, cost $23,800 and was stationed at Pier 1, North river. The second boat, the Zophar Mills, was put in commission in 1882 and is still in active service. The most recently delivered boat has a capacity of 9,800 gallons per minute and a nozzle pressure of 150 pounds. The fleet as now constituted is as follows:

Zophar Mills .....St. George, Staten Island.
John Purroy Mitchel....Battery park.
William L. Strong .....Foot of Grand street, East river.
The New Yorker.....Foot of Beekman street, East river.
George B. McClellan.....Foot of East 99th street, Harlem river.
James Duane.....Foot of West 35th street, North river.
Thomas Willett.....Foot of Bloomfield street, North river.
C. W. Lawrence.....Foot of East 135th street, Harlem river.
William J. Gaynor.....Foot of 37th street, Brooklyn.
Abram S. Hewitt.....Foot of Noble street, Brooklyn.

The Transit Commission has directed that the remaining grade crossings on the Long Island Railroad, Main line, from Jamaica eastwardly to the City line, shall be eliminated. The work will cover a distance of over 4 miles and is estimated to cost $2,000,000.

THEODOR S. OXHOLM, who has been Engineer in charge of the Bureau of Engineering, Office of the President of the Borough of Richmond, since its organization in 1898, has been appointed Consulting Engineer in the Office of the President. Mr. Oxholm, who

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is a past President of the Society, was accorded a surprise when he was requested to attend a meeting of the employees of the Bureau of Engineering at which he was presented with a handsome set, consisting of fountain pen and pencil, and the following resolution handsomely executed in ink and colors:

"The Civil Service Employees of the Bureau of Engineering, Office of The President, Borough of Richmond, City of New York, desire to tender their respects and congratulations to their Chief Executive, Theodor S. Oxholm, on his appointment as Consulting Engineer of the Borough of Richmond, assembled on the 1st day of February, 1923, and unanimously adopted the following resolutions:

"WHEREAS, Theodor S. Oxholm has served the City of New York for a period of nearly 39 years, giving continuously the utmost of his great ability as an Engineer and an Executive, and has been eminently successful in the direction of the large and varied Engineering projects undertaken.

"WHEREAS, He has been ever mindful of the needs and welfare of his associates, and by his tact and courtesy and an even tempered administration of his duties created a feeling of deep respect and admiration.

"BE IT RESOLVED, That Theodor S. Oxholm be suitably notified by his friends and associates of their pleasure and gratification in his appointment and assured both of their continued co-operation with him in his wider field of activity and their sincere affection and esteem for him as a friend and a man."

Mr. Oxholm thanked the employees of his Bureau for the tokens presented to him and expressed his appreciation of the assistance given to him in the administration of the Bureau by their faithful and efficient work.

C. B. J. SNYDER, Architect and Superintendent of School Buildings of the Board of Education, retired Dec. 31, 1922, after thirty-one years of service. During his term of office, Mr. Snyder superintended the erection of more than $200,000,000 worth of school buildings and developed details, originated features and created an artistic excellence in school architecture that are now accepted as standard design both in the United States and abroad. On Feb. 1, 1923, William H. Gompert was appointed Architect to the Board for a period of six months. CLARENCE E. DOBBIN is Deputy Superintendent of School Buildings.

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Borough of Manhattan.

Standard regulations for sidewalk construction have been prepared and will be available upon application to the Chief Engineer of the Bureau of Engineering.

The Repaving Program for 1923 anticipates the expending of $2,500,000 for repaving the streets in the borough.

Assessment work, sewers, regulating and grading to the amount of about $1,000,000, have been authorized and will be placed under contract in 1923.

The Aerial Map of the Borough continues to attract attention and favorable comment.

Plans, outlines and data for the 25th Greater City Anniversary are being collected. The loan of old photographs showing borough conditions previous to consolidation are earnestly solicited. Kindly communicate with the Division of Design if you have something of interest.

MEMOIR

BENJAMIN FRANKLIN CRESSON, JR.

Died January 26, 1923

Benjamin Franklin Cresson, Jr., Chief Engineer for the Port of New York Authority, died January 26, following an operation for appendicitis. He was forty-nine years of age.

Mr. Cresson, who was born in Philadelphia, received his education at Lehigh University and the University of Pennsylvania. After leaving college he served on the engineering forces of the Lehigh Valley Railroad from 1894 to 1897, at which time he was appointed transitman on the construction of the Reading subway in Philadelphia. In 1900 he was made assistant engineer in the office of Jacobs & Davies, consulting engineers, New York City, on preparation of plans, specifications and estimates for the proposed tunnels for the Long Island Railroad under the East river, New York City. In 1901 he was assistant engineer in re-survey plans for the completion of the Hudson tunnels under the North river (McAdoo tunnels). During the next nine years he was assistant engineer, alignment engineer and resident engineer in charge of precise triangulation on the North river, resident engineer in charge of a section of the sub-aqueous tunnels under the North river, and resident engineer on the Pennsylvania Terminal in New York.

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Mr. Cresson was appointed First Deputy Commissioner of Docks of New York City in 1910, and during his service in that capacity he visited Europe to study important harbors. He held that position until early in 1913, when he resigned and was appointed Engineer of the New Jersey Harbor Commission. Two years later he was appointed Chief Engineer of the Board of Commerce and Navigation of the State of New Jersey. He held that position two years, after which he resigned to enter consulting practice in New York City.

In his consulting practice Mr. Cresson served the Board of Harbor Commissioners of Wilmington, Del., Pacific Port Terminals, San Francisco, City of San Diego, Cal., Port of Tampa, Fla., and the Board of Harbor Commissioners of Camden, N. J.

He became associated with the investigation of the engineering features of New York harbor at the time of the formation of the interstate body which preceded the organization of the Port Authority and was responsible for the major part of the engineering plan made by that body and incorporated in the interstate treaty. He became Chief Engineer of the Port of New York Authority at its formation.

Mr. Cresson had been a member of the Municipal Engineers from October 25, 1911, to the time of his death.

INSPECTION

Radio Broadcasting Station of the American Telephone and Telegraph Company

December 2, 1922

The complete equipment of Station "WEAF", the broadcasting station of the American Telephone and Telegraph Company on Walker street, Manhattan, was thrown open to the Municipal Engineers on Saturday afternoon, December 2, 1922, and the methods and apparatus for broadcasting by radio were described and explained. Over one hundred and thirty attended.

The members were divided into small groups and were piloted through the building by guides, in accordance with a pre-arranged program and schedule. An opportunity was also afforded to visit the long-distance telephone operating exchange, as well as the local exchange, that are housed in the same building.

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The parties were admirably conducted, the different processes, methods and equipment explained by competent representatives of the telephone company and the inspection, which consumed over two hours, was most interesting and instructive.

Each member was presented with a pamphlet explaining by text and illustrations the workings of the exchange and the different steps involved in putting through a long-distance call.

The regular "WEAF" announcer was present in the radio studio and it was pleasant to meet the possessor of the voice that has become so familiar to many thousands.

PENSION SYSTEM OF BOSTON

Boston has a new law which establishes a contributory municipal pension system for city and county employees. It is applicable to all the employees, including firemen and policemen. It is estimated that the cost to the city the first year of operation will amount to about $1,308,000. After February 1, 1923, all who enter the city service will come under the new system; the firemen, policemen and school teachers may still continue to hold their non-contributory pension system. The employee contributes 4 per cent. of his salary and that amount bears interest at 4 per cent. compounded annually. Retirement may be claimed at the age of 60, and is required at 70. Upon retirement he receives an annuity, based on contributions plus interest and plus a pension in equal amount from the city.

The Department of Health, in a special effort to prevent the spread of hydrophobia by a mad dog recently found in the Borough of Queens, in co-operation with the A. S. P. C. A., picked up within the city limits, in a period of six months, over 33,000 abandoned and homeless dogs. We are informed that the A. S. P. C. A. annually destroys over 30,000 dogs, which, if not killed by this organization, would, in most instances, suffer considerably from inclement weather, street accidents, and hunger.

The Police Department announces that seven traffic towers will be installed on Bedford Avenue, Brooklyn, to control traffic in the same manner as on Fifth Avenue in Manhattan.

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NARROWS TUNNEL—ORGANIZATION*

Administration

ARTHUR S. TUTTLE, M., Am. Soc. C.E., M.M.E.N.Y., Chief Engineer.

HERMAN H. SMITH, M., Am. Soc. C.E., M.M.E.N.Y., Deputy Chief Engineer.

D. W. COE, M., Am. Soc. C.E., Resident Engineer.

WILLIAM J. SHEA, M., Am. Soc. C.E., Assistant Engineer.

FRANCIS H. PHIPPS, Assoc. M., Am. Soc. C.E., Assistant Engineer.

LEON K. MERRILL, Auditor.

WILLIAM M. CONANT, Statistician.

Consultants

GLEN E. BALCH, Dredging.

GEN. EDWARD BURR, M. Am. Soc. C. E., Trench Tunnel Construction.

WILSON S. KINNEAR, M., Am. Soc. C.E., Railroad and Trench Tunnel Design and Construction.

FREDERICK C. NOBLE, M., Am. Soc. C.E., M.M.E.N.Y., Tunnel Design and Construction.

HENRY B. SEAMAN, M., Am. Soc. C.E., Structural Design.

JOHN F. SULLIVAN, M., Am. Soc. C.E., M.M.E.N.Y., Project.

SILAS H. WOODARD, M., Am. Soc. C.E., Tunnel Design and Construction.

Design and Construction

JESSE B. SNOW, M., Am. Soc. C.E., Tunnel Engineer.

CHARLES D. DREW, M., Am. Soc. C.E., Principal Assistant Engineer.

WILLIAM MCK. GRIFFIN, Resident Engineer.

CLARENCE K. CONARD, M., Am. Soc. C.E., Railroad Engineer.

W. C. LANCASTER, Fellow, Am. Institute of Electrical Engineers, Electrical Engineer.

JOHN H. QUIMBY, M., Am. Soc. C.E., Designing Engineer.

ROBERT C. STRACHAN, M., Am. Soc. C.E., Assistant Engineer.

CHARLES J. MCGRONAN, M.M.E.N.Y., Assistant Engineer.

MELVIN D. CASLER, M., Am. Soc. C.E., Assistant Engineer.

EDWARD M. LAW, M.M.E.N.Y., Assistant Engineer.

HANS R. JACOBSEN, M., Am. Soc. C.E., Assistant Engineer.

* The organization as printed in the Third Quarterly Issue of the MUNICIPAL ENGINEERS JOURNAL for 1922 was in error; it should have been printed as above.

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"ROUT THE RAT" ACTIVITIES IN THE CITY OF NEW YORK

By JOSEPH M. LONERGAN, M.M.E.N.Y.

Supervising Chief Inspector, Department of Health, New York City

The present-day scientist is pointing with alarm to the great danger to the human race due to the amazing increase of destructive insects. While he is directing public attention, particularly, to the loss occasioned by these pests to growing crops, he has not been lax in showing the damage resulting to us from the depredations of these insects among our food products, dairy animals, wearing apparel, trees and, generally, materials entering into our daily life. He does not hesitate to announce that if a concerted effort is not made by the public at large to control these conditions it will not be many generations before these insects rule the world.

A great many of these insects have been allowed to exist through reason of the lack of fear, or through a feeling of indifference to their existence. This is not so, however, in the instance of rats, which are naturally abhorrent to almost all mankind. And therein has been the secret of the preservation of the race from utter destruction through bubonic plague.

The bubonic plague is celebrated in history as the "black death" of the early centuries. Its ravages through the years are well described. Once a person became infected thereby, no hope was had for him and within a very short time he passed away. It may well be said that very little advance, as far as actual cure of this disease is concerned, has been arrived at, even in these enlightened times. As proof of this, one has but to look at the great plagues which swept some of the European, Asiatic and African countries, wiping out myriads of people.

While the cure of the disease is almost impossible, the cause of it, its method of transmission and the manner in which it may be eliminated are well known. It is due to a microbe—the *major pestis*—found in the body of an infected rat. This rat, generally the host for a number of fleas, quickly dies of the plague, and as the body becomes cold the fleas leave it for a warm-blooded animal, with a marked preference for humans. These fleas, having feasted upon the rat, bring the germ of the disease with them and in biting a human being leave some of the germs in him. Thus is the flea an intermediate host and the carrier of the disease.

Can this disease be eliminated? Yes, easily enough, were all to work in concert, but difficult when one considers the attitude of

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the general public to depend entirely on the constituted authorities for the safeguarding measures necessary. In all of these, there is one object in view,—the elimination of the rat.

It is passing strange to note that the actual health menace due to the presence of rats is of less moment to the public than the destruction wrought by these rodents. It has been estimated by competent authority that the loss in the United States alone, due to rats is upward of $200,000,000 yearly, imposing a tax of nearly $2 per person upon each man, woman and child in this country.

A rat breeds about five times a year and in each litter there are from 6 to 19 young. These soon reach maturity and within a month or two are ready to perpetuate their species. Surveys made at different points through this country have convinced the authorities that there is at least one rat for every human being living here.

As a menace to America, the New York City Department of Health has always viewed, with considerable concern, the presence of plague in foreign ports. Ships from these ports, with cargo or passengers, enter the harbor of New York daily, creating a potential health menace increasing in intensity with the numerical variance of infected rats aboard the ship, the methods of their control or extermination and the efficiency of these methods.

During the war the Board of Health, realizing the menace involved, tightened its requirements relative to the docking of vessels from infected ports,—domestic and foreign. Greater care and attention were given to rat-guarding hawsers, lines, etc., of these ships, and the breasting-off of the vessel from the pier. But following these requirements to their logical conclusion presented problems of extreme difficulty to the shipping concerns of the harbor and threatened to impose an additional hardship upon commerce. The width of the slips in which vessels docked, the dropping of valuable cargo overboard, the impossibility of placing lighters alongside of the vessels, the difficulty in maintaining suitable watchmen at gang-planks, etc., to prevent rat entry from ship to dock and the expense involved were some of the factors tending to defeat proper control.

It was considered that the regulations governing the docking of these vessels were, at best, palliative, although it was recognized that the country's first line of defense against a rat invasion must be established at these docks. They sought to keep the rat upon the vessel, to multiply to infinity with the terrific inroads through destruction upon the cargo carried, leaving open the entry of the plague or infected fleas by the infection of a person while aboard

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the vessel, nor did they provide an adequate safeguard against the importation of rats through the medium of freight in which the rats had secreted themselves.

To offset these items and to provide a method of extirpation, or at least to exterminate a greater number of these rodents, a campaign was conducted to secure a suitable fumigation of the ships to be guarded. The Board of Health notified the consignees of these vessels that a fumigation by the Health Officer's Department would be taken in lieu of rat-guarding, breasting-off, etc., and would be a worthy contribution, by the shipping interests, to the preservation of the health of our city. In addition, it was made compulsory to so fumigate a ship prior to going into dry-dock for repairs, since there was no reasonable method of preventing rats from leaving a ship while so located.

For some time, sulphur was used for fumigation to the exclusion of other materials. The principal objection arose from the spoiling of food products, the destruction of seed, the discoloring of metal, and the bleaching effect on trimmings. To overcome these objections, sodium and potassium cyanide were tried and found excellent for the purpose. Under suitable regulation, this dangerous gas gave really wonderful results. It can be used in a ship carrying a varied cargo without harming any portion of it. This resulted in killing the greater number of rats aboard and furnished an additional safeguard in that any rats secreted within the cargo are reached and killed by gas. The use of this gas is attended with great danger and strict regulations governing such use are imperative.

The fumigation of a house or a ship follows the same general plan. Sulphuric acid and water are placed in a receptacle in the proportion of two parts acid to three parts water. Then all openings of the house, etc., to the outer air are closed tightly, except the exit for the operator, gummed paper generally being used in the case of buildings and tarpaulins on board ship. All persons, except the operator, are removed from the premises and he is equipped with a suitable mask and rubber gloves for his protection. He places one part of sodium or potassium cyanide in the receptacle holding the acid and water and leaves the premises, sealing the outlet behind him. The gas is generated immediately, with considerable heat, and as it is extremely volatile, seeks out every crevice, hole and crack. Every bug, rat, mouse, in fact, anything living on the premises, is reached and quickly succumbs to the gas. The nber of rats found dead in a ship fumigated for the first time a considerable time in service is extremely high.

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As a second line of defense against the plague, although not primarily directed toward the elimination of the rat, the Health Commissioner, Dr. Royal S. Copeland, considered that a trained body of men under competent supervision furnished the necessary safeguard. The ostensible head for this purpose was the Sanitary Superintendent of the Department of Health, Dr. F. J. Monaghan, who is the executive head of the department. He recruited a squad, provided them with an outfit consisting of snap and cage traps, bait, poisons, etc., and through Dr. Wm. H. Parks, in charge of the laboratories of the department, outlined the method of examination of the rats suspected of having plague.

The actual field work of the squad is under the control of Walter E. Richards, supervisor in charge. He has districted the city into areas with special reference to the water-front, and has assigned his inspectors to these areas. Surveys are made to determine evidences of rats. When located, traps are placed, generally of the snap or guillotine variety, and are tied or screwed to the floor and baited with bacon, cheese or some of the materials which the rat has been in the habit of obtaining in that area. Care is had to set these traps on a trigger edge, a hand file being provided to remove any burr which may form on the trigger, since otherwise the rat might be able to take the bait without starting the trap. The following day the traps are examined and any rats caught are tagged with a metal band upon which a number appears, and upon an accompanying card is given the number, the location from which the rat was obtained, the date and the name of the inspector. These are delivered to a central point in the district and taken by messenger to the laboratory at the foot of East 16th street, Borough of Manhattan.

In exposed areas where snap traps are liable to be dangerous to those entering in or working upon the premises, cage traps are used. It has been found that once a live rat is caught in one of these cage traps he seems to attract others of his kind.

If there be evidence of rats, but none are caught in the traps, these traps are shifted to other places within the same premises and, after cleaning, again baited. Considerable ingenuity is used to disguise these traps so as to fool the rat, who is a very wary creature and quick to notice any change in the conditions surrounding his habitat. Oftentimes, oil of anise or oil of rhodium is used near the traps to attract the rats, since these oils seem to be of value for that purpose.

Where food-stuffs are handled, trapping would be inconvenient and the use of poison bait dangerous, and recourse is had to a

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sticky material similar to tanglefoot for the catching of flies. This material is spread upon boards and placed on the floor where rats generally run. If a rat places one foot on this material, he is caught, since his struggles to free himself only result in his body becoming engulfed in this material. The rats are removed the next day by the inspector and the boards left for a new catch.

Along the docks, at dumps, and in similar places where a dead rat will not create a nuisance, poison bait is spread. While there is some value to almost every rat poison on the market, the department has found that the easiest bait to handle and one that seems to be of best value in view of the rat's apparent liking for it, is barium carbonate and flour. The barium, purchasable at any drug store, is mixed dry with three parts of flour in a clean receptacle. Enough water is added to make a dough and this is spread where the rats may reach it. Care is taken to see that once this mixture is wet the hands do not touch it, as the rats are slow to eat anything which has recently been handled by humans. The following day the location is surveyed, old bait removed and new bait placed. If it be apparent that this bait is not acceptable to the rat, chopped meat, cheese, vegetables, fruit, or some other material which the rat has been accustomed to, is substituted for the flour. Of course, this material will sicken children, dogs, cats or poultry and the persons in charge are notified of this and warned to take precautions accordingly.

Rats are cannibals and will eat any of their kind injured beyond recovery or dead. Taking advantage of this fact, several firms have placed on the market materials which, eaten by the rat, tend to produce diseases in it which will cause its death and spread the disease to the rats feeding upon the dead member. The department is experimenting with several of these, but is not in a position to approve of them. Most of them tried soon become attenuated and of little value after killing the rat eating them.

While no attempt is made to trap dwellings inland from the water-front, still the supervisor personally visits any premises where rats are reported to have bitten children. It has been claimed that once a rat has bitten a human being he seeks blood to feed upon. While we have not been able to conclusively prove this statement we find that we get better results in trapping these houses, in which the rats have attacked humans, by baiting the traps with red beef.

As stated before, there is no attempt to have this rat squad clear the city of rats, which would be a herculean task. The purpose of their work is to catch rats for examination at the laboratory. In this way an outbreak of human plague will be prevented, since

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plague in rats generally appears within any area about six months before it attacks the people of that area. Consequently, if any plague rat be found the area from which he comes will be segregated, and every living thing therein, after the human population is removed, destroyed through the use of cyanide gas, sulphur, carbon bisulphide, carbon tetrachloride poisons, etc. Plans for such an eventuality have been prepared and are in readiness if such a possibility arise. It is hoped by these means to do away with the old method of fighting the plague, which was to burn down the entire area in which it appeared.

The work at the laboratory is under the immediate supervision of Herman Gerber, bacteriologist in charge. A separate building fully equipped for the purpose intended has been provided for this work, and all necessary precautions for the protection of the workers and surroundings are carefully followed.

When the rats are delivered to the laboratory they are immediately immersed in a cresol solution and left there for one-half hour. The purpose is to kill any fleas that remain on the rat.

After removal from the disinfectant the rats are tacked on boards, each labeled in accordance with the tag accompanying the rat showing the location from which it came and the date trapped.

The autopsies then are proceeded with as follows:

1. The skin over the ventral surface of the rat is dissected back exposing the cervical glands, the inguinal and the axillary regions.
2. The abdominal cavity is dissected, exposing the spleen and the liver.
3. The thoracic cavity is dissected.

Plague lesions are looked for in all of these procedures. If any suspicious lesion is noted, a complete bacteriological examination is then made, and animals are inoculated. All autopsied rats are destroyed in an incinerator immediately after examination.

Infinite pains are taken to protect the city from the presence of plague. This involves considerable time, effort and expense, but it is money and effort well spent when one considers that the presence of one case of human plague in the City of New York would ruin the city commercially for a long time to come, as well as entailing a vast amount of suffering and death.

A study of the rat and recourse to the voluminous literature on the subject firmly establishes the conviction that rat-proofing and the removal of all food-stuffs beyond the reach of the rat offer the only solution of this problem.

It would be impossible in a city of the character of New York to rat-proof each individual building except under the stress of a

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great epidemic of plague. But every plan filed for a new building or for the alteration of an existing building might well be rejected unless suitable provision for rat-proofing is made.

To establish a basis for rat-proofing the following suggestions, not new, but found of service, are offered by the Department of Health:

> The floor of the cellar or lowest story in every building and the side-walls for several feet above the ground surface, should have at least three inches of good concrete, or should be provided with wire mesh not less than No. 12 gage and not greater than ½ inch in size, such mesh to extend up the side-walls for several feet above the level of all outside, connecting platforms; all openings into cellars or basements to be properly screened with such mesh or with mesh of heavier gage; openings into cellars or basements for ingress or egress to have doors metal covered and fitted with springs or checks to make said doors self-closing.
>
> Openings in the wall for steam, water, sewer pipes, electrical wires, etc., to be tightly closed with cement in which broken glass has been mixed.
>
> Dead spaces beneath show windows to be opened or metal lined.
>
> No material to be used as covering for yards, sidewalks, passageways, courts, alleys, etc., which would permit of rat harborages.
>
> All openings in roofs to be screened and to be kept closed when not in use.
>
> All natural or accidental openings in existing buildings to be properly screened or closed with cement; all rat harborages in and around such buildings to be removed; lumber in lumber yards to be piled so as to prevent rats harboring therein or thereunder; storage bins to be properly constructed with metal lining and tight-fitting metal covers; all boxed, crated, sacked or loose merchandise to be inspected and moved at regular intervals.
>
> All boxed-in areas to be removed or to be opened, cleaned and enclosed in heavy, ½-inch wire mesh.
>
> Materials not to be piled on the floor but to be placed so as not to harbor rats and elevated from the floor.
>
> Chicken and pigeon coops and the food therein to be protected from rats.
>
> All garbage to be kept in proper containers.

All of the docks of the City of New York are not rat-proofed, but the City government has taken the rat into consideration in designing and building new docks and in the alteration and repair of old docks. Through this procedure it will not be very far in the future before all docks around this city are protected.

Starve the rat, build him out and the "Rout the Rat" campaign will have achieved its purpose.

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PORTION OF THE SHANDAKEN TUNNEL OF THE CATSKILL MOUNTAIN WATER SUPPLY SYSTEM. THIS TUNNEL IS 18.1 MILES LONG AND IS THE LONGEST TUNNEL IN THE WORLD. EXCAVATION FOR THE ENTIRE LENGTH HAS BEEN COMPLETED AND PLACING OF CONCRETE LINING IS NOW IN PROGRESS.

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PORTION OF THE SHANDAKEN TUNNEL, SHOWING TEMPORARY TIMBERING. THIS TUNNEL IS BEING CONSTRUCTED BY THE BOARD OF WATER SUPPLY AND WILL CONVEY THE WATER FROM THE ROONDARIK RESERVOIR TO THE ROSENDALE CREEK

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GROUP OF THREE FOSSILS FOUND IN THE RIVERSIDE QUARRY WHILE QUARRYING FACE STONES FOR THE GILBOA DAM OF THE SCHOHARIE RESERVOIR. THE APPROXIMATE AGE OF THESE FOSSILS HAS BEEN ESTIMATED BY THE GEOLOGISTS AS THREE HUNDRED MILLION YEARS.

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upon his ability to weigh the various factors which should be taken into consideration. There is indeed a scientific basis for every city plan and there are always one or more problems of a purely scientific nature involved, as will be seen later, but the elements are so numerous and so complex that the result will generally depend upon considerations other than the theoretically correct plan.

In the Borough of Queens and City of New York generally we have in addition to the problems of providing for the orderly and economic development of the City, with provision for future growth, encouraging development and preventing nuisances, to consider the legal aspects of each case, for we are much limited by the charter, current legislative enactments and decisions of the courts. We must also weigh with care the cost, who is to pay and their ability to pay, for these are matters which our Borough President, Maurice E. Connolly, is constantly weighing and considering before giving his approval to any city planning project.

One who attempts to carry through even a modestly generous street plan must go through emotions not unlike those of Galileo trying to convince the world that the earth is round. No matter how clearly you may see the need of certain improvements you may be sure that your plan will be viewed by selfish property-owners only in the light of the assessment that will be levied and no matter what the benefits that may come to them, in general they will see only the first cost. This is the cross we city planners bear in what would otherwise be one of the most attractive branches of professional engineering.

In planning for the Borough of Queens, we have had before us at all times the fact that the design had to be acceptable to the property-owners, else it could not be carried out. It is simple indeed to draw an ideal plan, but not so easy to draw a good one that can be carried into effect. Great landscape architects and city planners frequently draw beautiful schemes for the development of municipalities, accompanied with impressive perspective drawings and descriptions, and then they simply "fold their tents like the Arabs and as silently steal away"; but we, who are engaged in work of this character, must continue to live with our plan and if possible carry it into effect. We therefore realize how important it is that the plan be such that it can be carried out and financed.

The author ventures to say that less than 10 per cent. of the schemes of city planners have ever been realized. We are, there-

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fore, always viewing our designs from the position of one who has a property interest at stake, as well as from that of an idealist who would cry out for more parks, more open spaces and wider streets.

The method of preparing the topographic base map in Queens was by plane-table stadia survey, controlled by elaborate chain traverses, which in turn were controlled by a very precise system of primary triangulation. Upon this survey the street locations were tentatively designed and later run out and monumented in the field by accurate chaining with specially devised chaining tables. The street locations have been based as far as possible upon the surveyors' locations of the existing streets.

In designing the highways of the borough the method has been to hold as nearly as possible all existing streets and to widen these, where necessary, to provide arteries for traffic. The undeveloped and sparsely built areas are mapped so as to give convenient and natural connections between the developed areas. The street widths are proportioned according to the probable traffic which the highways will ultimately be called upon to accommodate.

It has been our endeavor to encourage individuality in the lay-out of property, so that there should be a diversity of scenery and not a monotonous checker-board of streets and avenues, but we have always subjected new methods of layout to careful scrutiny and endeavored to prevent freak street plans which might result in dwarfing a community or depreciating the values of adjacent property.

The Borough of Queens is a large city within itself. It consists of 75,000 acres, or about one-third the area of Greater New York, the same area as Philadelphia and three times the area of Boston. In the value of its commercial products it stands fifteenth among the cities of the United States. At the time of consolidation only about 6 per cent. of the borough had been officially mapped. The remainder consists of about twenty or thirty scattering villages entirely disconnected except by narrow, crooked highways. The problem is to connect these street systems not only into a general plan, but also the accuracy of the physical work must be such that a homogeneous and comprehensive street system will result.

St. Albans offers us an excellent example of the manner in which streets were laid out in portions of the Borough of Queens when no city plan existed to guide the property-owners. It is on the outskirts of the borough. The author believes it can plainly be seen

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that each owner has laid out his property with the one thought of making the greatest number of lots. There is not a highway more than 60 feet in width; almost all are only 50 feet. No attempt is made to articulate the streets and the trend of traffic is given no consideration whatever. The unfortunate feature about such lay-outs is that, once they take root, it is very difficult to change them because houses are built upon such streets and even the absolutely essential articulations become costly. In almost every instance when the time for the street opening arrives, the original owners who thus laid out their land have gone and innocent purchasers are made to pay for the lack of foresight or wilful disregard of the public need as evidenced by the original plan.

The 51st Street section will illustrate a problem which resulted from a condition of this kind. It is a small, built-up area, wholly discordant with the general plan and yet so intensively developed that to carry our streets directly through the existing layout, as we would wish, would be costly indeed. So we have been forced to unite the incongruous elements into such harmony as may be possible, obtaining one wide thoroughfare carrying straight across the area and providing fair access. There is room for difference of opinion as to the wisdom of the method adopted in this as in many other of our problems, but in criticizing, one must keep clearly in mind that the cost of any contemplated plan must be borne by the owners of adjacent land deemed to be benefited thereby. Therefore the ability of such owners to pay the bill must be taken into account.

To give a simple example of a street that was built with entire disregard of the surrounding territory, old 14th street in College Point was laid out by the property-owners from Schleicher Court to the property line 100 feet south of Avenue C. That was all the land owned by the property-owners and could not therefore give access through to Avenue C. The owner of the land along Avenue C had no interest in providing access through this street and would have lost two full lots had he laid out a street as a continuation of 14th street. This short street has been well built up with houses. It formed a cul-de-sac and the residents desired an outlet into Avenue C. The only solution was a legal opening proceeding giving the City title for street purposes to the two lots which formed the barrier. The remainder of the street was dedicated to public use. A proceeding was initiated, the necessary maps prepared, commissioners appointed by the Court, testimony taken by the commissioners and

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an award of $850.00 each was made for the two lots. Nominal awards of $1.00 and $25.00 were made for the dedicated portion of the street. On the map showing the boundary of the assessment area, there is written in each lot the amount of money which its owner had to pay in order to acquire the two lots referred to. The overhead charges are almost equal to the cost of the land. It is a condition that frequently occurs in the case of short streets opened by proceedings. Such proceedings are indeed costly and made necessary almost entirely because of the lack of a city plan or because of a poor one. In this proceeding no buildings were taken and the City bore no part of the expense. The lesson to be drawn from this is that *city planning pays.*

This leads the author to recall other days, when a large proportion of the cost of widening and extending old streets and opening new streets was borne by the City at large. Statistics show that during the years 1905 to 1912 the City of New York as a whole paid $6,112,952.00 toward the cost of legally opening streets in the Borough of The Bronx and $2,594,500.00 in the Borough of Manhattan, while for the Borough of Queens only $292,322.00 was paid. It must be remembered that a great many wide thoroughfares were acquired in the other boroughs under this more liberal policy at a time when only a very small well-developed area of Queens was even mapped, so that but few streets could be acquired.

In the author's opinion the Borough of Queens is suffering an injustice because it helped to pay for many wide streets in other boroughs, whereas, in the present period of its intensive development, it is receiving almost no aid whatever. The sad part of it is that such a condition has prevented the acquisition of many new and vitally needed thoroughfares. It has resulted in placing upon the map far too few streets wider than 60 feet. There is little doubt that a broader policy of assisting property-owners in this work would result in real economy.

In Queens we have constantly struggled with the Board of Estimate and Apportionment of the City to get financial assistance in holding at reasonable width most important highways, especially those leading out into the borough, like Flushing, Metropolitan and Ridgewood avenues. We try to educate property-owners to appreciate the advantages to them resulting from wide thoroughfares. They usually learn it too late. Too many are inclined to feel that almost any kind of a street answering the need of the hour will do.

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Blind to their own future interests, they argue against and oppose improvements that would quickly repay them the money invested.

Looking back into the history of the controversy over many projected wide thoroughfares we generally find two opposing forces,—on the one hand the property-owner insisting that a street width greater than 60 feet was solely of benefit to the City at large and therefore refusing to pay for the widening, and on the other hand the Board of Estimate and Apportionment insisting that it was entirely of local benefit that should be assessed accordingly. The best interest of all would be served by a reasonable attitude on the part of each, but the result is too often that the street is narrowed to a width sadly inadequate.

Some time ago an irate citizen who owned land on Jackson avenue near the easterly end of the borough came into the author's office to protest against its widening. He presented the usual arguments against it. The author asked him if he knew that the property on 42nd street near Madison avenue in Manhattan was assessed at $12,000.00 per front foot, whereas that on 43rd street in the same block was assessed at $4,000.00, the difference being that 42nd street is 100 feet wide, while 43rd street is only 60 feet. He laughed and said that the value on 42nd street was on account of the location of the Grand Central depot. The author explained that the reason the Grand Central depot was located at 42nd street was because the street was fixed at 100 feet a half century before the depot was located. He was still unconvinced, so the author took out our land value map and showed him the assessed value of land on 23rd street (another 100-foot street) and compared it with 22nd and 24th streets. Here again the value of 23rd street was also quite double. He went away a firm advocate of the 100-foot width for Jackson avenue.

Another problem is illustrated by what is now known as Cross-Bay boulevard. From a plan of the borough it can be seen that the Fifth ward, or Rockaway peninsula, was entirely separated by water from the remainder of the City of New York. Of course a railroad line runs across Jamaica bay, but there is no vehicular connection. It is necessary for vehicles to pass into Nassau county, an additional distance of 10 miles, in order to go from Manhattan, The Bronx or Brooklyn to this Rockaway peninsula.

For many years, Rockaway people have dreamed of a short-cut across the bay to the remainder of the City of New York. An aero-

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plane picture shows the islands of Jamaica bay along which any highway must be constructed in order to provide access to the 10 miles of ocean front which belong to New York. About 1915, Borough President Connolly conceived that a boulevard could be constructed to fill this need. Several years prior the City of New York entered into a lease with the Broad Channel Corporation, for about 1,032 acres of land including about 2¾ miles of this boulevard. Mr. Connolly took the matter up with the lessee, the Broad Channel Corporation, which showed its willingness to help to secure such a boulevard. It offered to cede its rights in the bed of the street and to do certain grading within its territory.

A final map was submitted to the Board of Estimate and approved, and final negotiations were begun with the lease-holders. Meanwhile, preliminary authorization was granted by the Board of Estimate to prepare plans for the road. During the negotiations the Broad Channel Corporation partly constructed the road and moved building from the bed of the street.

The road across the bay is about 4¼ miles long and will be constructed on concrete piles with 36-foot roadway and abutting sidewalks. The trestle will be built upon one side of the 100-foot right-of-way, so that in future its width can be doubled without disturbing the existing structure. Upon the filled-in portions the street will be constructed 100 feet wide. The project will cost over $2,000,000.00.

The author invites attention to a development called "Forest Hills Gardens". It is a rural development of unique and exceptional merit, made possible by the Sage Foundation and carried out in every detail upon a definite and consistent plan the purpose of which was to create a community of the English suburban type like Hempstead Gardens, near London.

It is unquestionably one of the most artistic and strikingly beautiful plans in the vicinity of New York. On account of its exceptional character it was deemed proper to permit certain thoroughfares of small width such as would not have been permitted on the final maps of the borough but the property was covered by set-back restrictions and covenants which assured the perpetuation of the highest type of development. The disadvantages of narrow streets were offset by other evident advantages of the plan, the roads being so laid out as to create striking vistas and giving each house a pleasing outlook.

In spite, however, of its irregularities and the comparatively narrow streets the plan as a whole is so designed as to afford proper

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connection with surrounding territory through Continuation of Fortieth avenues and streets running east and ... examples of the proper connection between rectangular and curvilinear thoroughfares.

... difficulties encountered in city planning due to ... property owners of assessment area and general ... Ashland street as an example. ... bounding the southerly boundary of Forest ... not connect with any continuing street. ... original plan eighteen or more houses were ... save expense and make a better plan it ... under the park, in order to make a better ... South, a wide street leading to Queens ... Parkway.

... this proceeding took place just ... opponents of the administration ... among property-owners and claim- ... for the benefit to the park ... therefore, be entirely a City ... and it was necessary for ... show the area of assessment ... about 40 feet long. When ... New York, as owner of the ... paying one-half of the cost ... with the cost of one-third ... only 60 feet in width, ... were paid for, the citizens ... It may be inter- ... between 1 o'clock

... the Commissioners ... ners would consider ... ...ety and elasticity ... found in Phila- ... ...ses were found ... so a method ... would suppose ... building or ... the rear.

... ...ers' map of ... ...ly does and

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connecting streets have been designed meeting alternate streets with park spaces, for tree planting, between.

One of our most interesting problems is the treatment of the 30 miles of ocean front on our Rockaway Peninsula. In recent years the ocean has made great inroads upon the built-up section of Rockaway Beach destroying about $5,000,000.00 worth of land and buildings and depreciating the values of the remaining lands on account of the uncertainty of this erosion. Some years ago we made extensive studies of this erosion and recommended a treatment for protection. An ocean promenade is planned for the entire front and we are endeavoring to induce property-owners interested to have the City acquire the necessary land. To show the rapidity with which conditions change, the author might say that 11½ years after a picture was taken showing a house menaced by the sea the high water-line had moved out-shore again a distance of about 500 feet.

Another map we made showed the treatment proposed for Grand Central Parkway, a highway extending from Forest park eastwardly nine miles along the backbone of the island to the Nassau County line. Some portions of it have already been laid out by property-owners. It is 150 feet wide and when constructed will be one of the finest parkways of the City. From it, on a clear day, one can see the Atlantic ocean, Jamaica bay and many remote points of interest.

In passing, the author wishes to state that street-naming and house-numbering gave us much trouble. The area is so great and the layout so diversified that the problem was a difficult one. We quickly ran out of suitable names for streets before the borough was half mapped and were flooded with complaints about the proposed name changes. A unique solution has been worked out. A system of numerical names was devised upon a principle of elasticity, so that irregularities of layout are absorbed by repeating the numerical street name where necessary for three consecutive *streets*, discriminating between them by calling the first "Street", the second "Place" and the third "Lane". In like manner the *avenues*, which are the highways leading east and west through the borough, are designated "Avenue", "Road" and "Drive". Some small and large gaps in the numerical system were forced upon us but, so far, the system has worked well. Its main object of indicating the approximate, or exact, location of any address is accomplished.

In the Borough of Queens we not only endeavor to control the improvement of the street surface, but we seek to co-ordinate the underground as well. We have designed a normal street inter-

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Board of Estimate

and in the

map before them

on the ground

Yet if this be done it

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In Richmond the situation is sad, by reason of the fact that so little of the borough has been mapped. Richmond has not been maintaining as large a topographical force as Queens, and the result is that even the arteries have hardly been finally laid down,—and now they are experiencing a land boom. The speaker does not know what is going to happen, but there is great activity at the present time in the sale of lots, and there is a flood of these maps coming through which overtakes the borough without any comprehensive street plan. Their difficulties are enormous. The law is most beneficial, and today not one of these maps can go through without it fits into some rational plan, and we may regard Richmond, possibly, as being saved, so to speak, through this legislation which is now giving it control and which did not exist until about four years ago.

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Paper 130

PRESENTED OCTOBER 26, 1921

THE DESIGN AND CONSTRUCTION OF AN IMPORTANT SYSTEM OF SEWERS IN BROOKLYN KNOWN AS THE RALPH AVENUE SEWER SYSTEM

By JOHN C. RIEDEL,* M.M.E.N.Y.

WITH DISCUSSION BY NORMAN B. GARDINER, VICTOR H. REICHELT, PHILIP P. FARLEY AND THE AUTHOR

The sewerage system of the old City of Brooklyn, as the City was constituted about the year 1860, became the subject of much discussion in engineering literature in the succeeding decades. It was designed in the late fifties and was among the first to be developed along lines based upon experience. The experience, however, was not acquired in the United States, but was obtained in the City of London in the early fifties by observations of the flow in storm sewers by John Rowe, Surveyor of the Holborn and Finsbury Sewers. Mr. Rowe concluded that as a rate of rainfall exceeding one inch per hour was a rarity in London, such rate would be a reasonable maximum to be used in the design of storm-water sewers.

Subsequent gagings of London sewers by Sir Thomas Bazalgette and others led Thomas Hawksley, President of the Institution of Civil Engineers and one who was regarded as the most eminent hydraulician of his day, to conclude that it would be safe to design storm sewers to carry a rainfall of one-half inch per hour reaching them. He therefore devised, in about 1856, a formula, based upon tables prepared by Mr. Rowe, which expressed the relation between the diameter and slope of the sewer and the extent of the drainage area.

James P. Kirkwood, Past President of the American Society of Civil Engineers, and Engineer of the Department of City Works of Brooklyn for many years, submitted a report in 1867 upon the water works and sewers of Brooklyn, in which he stated that the

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sewers of Brooklyn were designed upon the Hawksley formula and would care for a rainfall of one inch per hour, one-half of the rainfall reaching the sewer within the hour. The designs and plans were made in 1857 and 1858. The sewers in the old City of Brooklyn were designed to receive the combined storm and domestic flow.

For purposes of record the Hawksley formula is here given in the form in which it was generally used, viz, $\log D = \frac{3 \log A + \log N + 6.8}{10}$ in which "D" equals diameter in inches of circular sewer, "A" equals drainage area in acres and "N" equals distance in which the sewer falls one foot.

No records of American experience were available in 1858 of the quantity or intensity of rainfall within short periods. Before many years had elapsed—in fact in the early seventies—it became evident that the sewers of Brooklyn were inadequate to care for storms which had occurred several times in some years. Colonel Julius Adams, also a Past President of the American Society of Civil Engineers and Chief Engineer of the Department of City Works of Brooklyn in the seventies, and who had been charged in 1857 with the preparation of plans for the sewering of Brooklyn, changed the Hawksley formula to one which he stated gave slightly less sizes for smaller areas and increased sizes for larger areas, experience having shown that such modifications were desirable.

The Adams formula was used for a time, but subsequent studies led to a further modification of the Hawksley formula until it became $D = \frac{3 \log A + \log N + 8}{10}$ the literal factors having the same meaning as in the original Hawksley formula and in this form it became known as the modified Brooklyn formula and was used in Brooklyn until some years after the consolidation of the several cities and towns now comprising Greater New York.

Flooded areas in Brooklyn increased in extent and number and successive attempts were made to relieve them, but the absence of controlling data and an adherence to the earlier principles of design made these attempts incomplete.

Between 1900 and 1906, under the supervision of Chief Engineer Henry R. Asserson, M.M.E.N.Y., serious though intermittent studies were made of the entire subject of rainfall and run-off in their relation to sewer design. In 1906, Edwin J. Fort, M.M.E.N.Y., was appointed Engineer of Design and after his appointment a modified design was completed for relief sewers for central Brooklyn,

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covering an area of about 3,500 acres, which contained the worst flooded areas of the borough, and it was in connection with this design that certain principles were determined which have been generally followed since.

It was clearly recognized in the early 1900's that all the formulae used in Brooklyn had produced sewers not large enough to care for more than one inch of rainfall reaching the sewer in one hour. Records of rainfall kept in Brooklyn since the early nineties and in Manhattan since 1869 were studied and curves of frequency and intensities were developed. The intensity curve whose equation, expressed in the Talbot form, is $R = \frac{150}{t + 20}$ where "R" is the rate in inches per hour maintained during time "t" was taken as the ten-year curve, that is, storms of greater intensity do not occur in Brooklyn on an average more than once in ten years.

After an examination of the several formulae available in 1906 for the determination of run-off from municipal areas, the choice narrowed to the "Berkli-Ziegler", the "McMath" and the so-called "Rational" formula based upon the proposal of the late Emil Kuichling to design sewers upon a rational method. It was felt that the "Rational" method would be, by far, the best and most satisfactory one, but in the absence of knowledge concerning the very essential factors, it was deemed best to limit its use to comparative purposes for the subject in hand and adopt generally for the major areas the "McMath" formula which had been extensively used by engineers since its introduction in 1887.

Mr. Kuichling was a frequent visitor to the Sewer bureau in Brooklyn during the period from 1906 to 1913, and many discussions were had with him upon the "rational method of designing sewers". He advised that the rational formula, if used at all, be used with a great deal of care. He deplored the absence of experimental and observational data and agreed that until such data were available, it would be wiser for the bureau to use the "McMath" formula for determining the run-off from areas the extent of which would be limited by their slope.

The "McMath" formula, as published in the *Transactions* of The American Society of Civil Engineers, is $Q = A\ c\ y \sqrt[5]{\frac{s}{A}}$, where "Q" equals cubic feet of water reaching the sewer per second from "A" acres, "A" equals area drained in acres, "c" equals proportion of rainfall that will reach the sewer, "y" equals cubic feet

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of water falling upon an acre of surface during the period of greatest intensity of rainfall—practically the same as the rate of rainfall in inches per hour—and "s" equals slope of the area "A" in feet per thousand.

The factors that were used in Brooklyn in the design for the relief sewers were "y" equals 3, "c" equals 75 per cent., and "s" equals 5 to 50 feet per thousand feet, depending on the slope of the area.

The "c equals 75 per cent." was arrived at by determining the proportion of the several kinds of impervious areas in the district and applying the degree of imperviousness agreed upon.

Twenty-four typical blocks were studied and carefully plotted so as to show the several kinds of impervious areas. The results were as follows:

Class of Surface	Total Area—Per Cent.	Degree of Imperviousness—Per Cent.	Run-off Entire Rainfall—Per Cent.
Roofs	40	95	38.0
Yards and unpaved surfaces.	22	10	02.2
Roadways and sidewalks....	35	90	31.5
Paved alleys	3	90	02.7
Total			74.4

The "y equals 3" was determined from the rainfall curve for a period of 30 minutes. The main outlets and some of the smaller tributary relief sewers have now been in service for four years and are functioning very satisfactorily.

Mr. Asserson resigned as Chief Engineer late in 1906 to engage in a number of large contracting operations and in 1907 Edwin J. Fort succeeded as Chief Engineer.

In 1907 the general re-design of the sewerage systems was undertaken for all the outlying districts of Brooklyn where no extensive sewer construction had yet been contracted for. Among the first districts to be studied was that part of Brooklyn lying generally to the south of Eastern parkway, west of Rockaway parkway, north of Flatlands avenue and Paerdegat basin and east of Brooklyn avenue, with a small area near the northwest portion extending to Nostrand avenue.

The area comprised about 2,200 acres, with elevations above mean high tide of 115 feet at Eastern parkway and of one foot at Flat-

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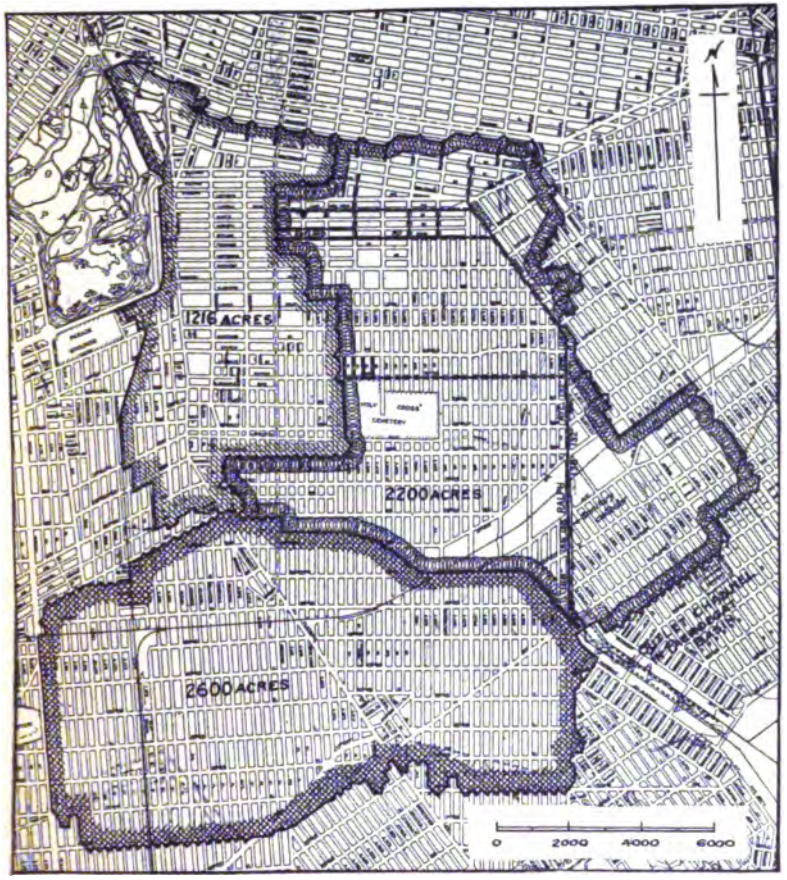
lands avenue. Surface slopes in the northern portion of eight per cent. were not uncommon and the district sloped quite rapidly from the ridge near Eastern parkway to East New York avenue. The fall in one avenue, in a distance of 1,800 feet, was 75 feet. The fall south of East New York avenue was at a much less rate. The Long Island railroad runs diagonally across the southern part



DRAINAGE DISTRICTS TRIBUTARY TO TREATMENT PLANT

of the district and the land south of the railroad was at so low an elevation that it was deemed impracticable to provide for combined sewers for the whole drainage district.

The entire area in 1907 was but sparsely settled. The fringe on the highest ground near Eastern parkway gave evidence of near development, but the transit facilities were so meagre that any

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estimate made as to future development would be mere speculation. Subway systems in Nostrand avenue and in Eastern parkway were not even suggested and it was thought that the area would generally develop upon a semi-urban basis, with houses on every 40-foot plot, and with asphalted streets and cemented sidewalks with ample tree spaces. The area south of the Long Island railroad was thought appropriate for manufacturing and industrial purposes, which areas would probably have extensive unpaved yard spaces.

After study and consideration a combined system was provided for the area of about 1,800 acres lying generally north of the Long Island railroad. A separate sanitary system was provided for the area of about 400 acres lying south of the Long Island railroad. This separate system was designed to include a sanitary sewer which would intercept and receive the domestic sewage conveyed by the combined system. A storm-water system was provided for the area south of the Long Island railroad, which system would have a capacity to receive and care for the storm water from the combined system. The main outlet for the district was designed to lie in Ralph avenue south of Remsen avenue—hence the name "The Ralph Avenue System of Sewers", by which the system is usually designated.

A sewage pumping-station was planned to be built near Flatlands avenue, Ralph avenue and Paerdegat basin; the sewage collected here to be disposed of at the station by an appropriate method or to be conveyed to Barren island through an interceptor to be built in the future. The pumping-station will receive the domestic sewage from an area of nearly 4,800 acres already mapped and from a district adjacent to Jamaica bay not yet mapped.

Quite near the proposed location of the sewage pumping-station was the terminus of the old outlet for the combined sewers serving Flatlands and a part of Flatbush, comprising an area of about 2,600 acres, bounded generally by Foster avenue, Paerdegat avenue, Glenwood road, Ralph avenue, Avenue "N", Flatbush avenue, Flatlands avenue, Avenue "O", and Ocean parkway. The invert elevation of this outlet was about four feet below high water at its point of discharge into a creek which was intercepted 300 feet away by the main line of Paerdegat basin. It was planned to extend this outlet sewer into the new system, intercepting the domestic sewage with appropriate devices and convey it to the sewage pumping-station. Tide-gates were planned on the connecting storm-water sewer to prevent the inrush of tidal water into the pumping-station.

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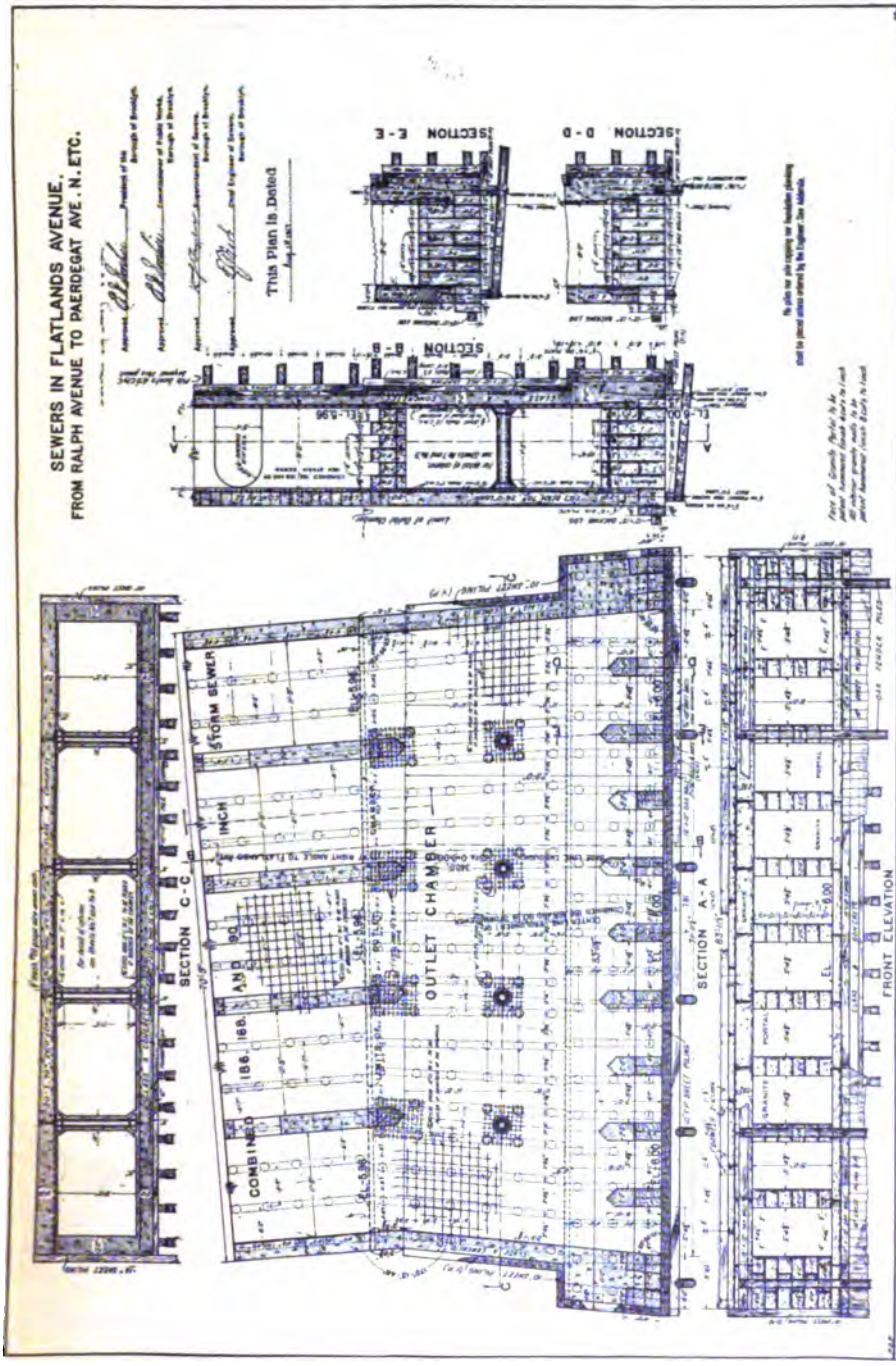

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Tide-gates were somewhat of an innovation in the City of New York; elsewhere, in other parts of the country, they have been used with some measure of success. The necessities existing in Brooklyn prompted the design for their use near the Paerdegat basin, and a real trial was desired before any steps were taken to introduce them generally into combined sewer systems, the domestic sewage from which must be intercepted for treatment before discharge into tidal waters.

It was further planned to relieve serious flooded conditions which were increasing in several sections of Flatlands and Flatbush by the construction of a storm-water intercepting sewer, beginning at Foster and Flatbush avenues, where it will receive the storm water from 1,216 acres and continuing to the intersection of Ralph and Flatlands avenues, where in capacity it would be equivalent to a circular sewer 186 inches in diameter. At Flatlands avenue and Paerdegat Avenue North, a junction was planned of this 186-inch sewer and the 168-inch storm sewer serving the main territory of the Ralph Avenue district, together with a 90-inch storm sewer from the area of 480 acres south of the Long Island railroad, where it was planned to construct storm-water and separate sanitary sewers. It was also planned to construct from the junction mentioned to the head of Paerdegat basin about 300 feet distant, a structure uniting the 186-inch, 168-inch and 90-inch storm sewers under one roof and on one foundation. This outlet has a capacity of 2,800 cubic feet of storm water per second which it will receive from an area of nearly 6,000 acres. This rate of delivery would yield about 75,000,000 gallons per hour.

Paerdegat basin has never been dredged, but an old creek wound its way in and out of the lines of the basin. In order to produce an effective outlet for storm water beyond the portal of the new sewer, it was planned to dredge a channel within the lines of the basin—the channel to follow the old creek generally where it lay within the basin lines. Any bends in the creek that would seriously impede the flow were to be straightened out. The width of the channel planned for the bottom was 35 feet and the side slopes called for were 1½ horizontal to 1 vertical. The elevation of the bottom of the channel planned was minus seven feet.

The fundamental assumptions and determinations used in the design of the combined, the storm and the sanitary sewers were as follows:

For Storm and Combined Sewers.—The "McMath" formula for run-off was used to determine the quantity of storm water to be

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cared for in the sewers. The factors in the formula were matters of prime importance and after due consideration the following were adopted for the major areas: "y" equals 3, "c" equals 50 per cent. and "s" equals as determined for the particular area under study and varying from 5 feet to 80 feet per thousand. The "c equals 50 per cent." was determined upon the conclusion that the general development of the area would be of a residential type with detached houses and surrounding lawns. For the smaller areas the rate of rainfall was determined from the intensity curve for the expected time of concentration at the sewer.

The outlet into tidal water at Paerdegat basin and Flatlands avenue was designed to have its inner top at the elevation of mean high water. The hydraulic grades and gradients of the sewers were determined with the elevation of mean high water as a base; all changes in size of sewers were made in reducers and the entire system was designed so that each sewer could deliver its flow into its outlet without being compelled to create a head and thereby diminish its capacity.

The velocities expected in the sewers were determined by the Chezy formula, viz: $V = C \sqrt{R S}$. Where "V" equals velocity in feet per second when sewer is flowing full, "C" equals coefficient determined by Kutter's formula. "R" equals hydraulic radius and "S" equals Sine of slope.

The coefficient of roughness n in the Kutter's formula was taken to be: for brick work 0.015, for concrete 0.013, and for vitrified pipe 0.013. Gradients were planned that would produce velocities of not less than 2½ feet nor more than 12 feet per second.

For Separate Sanitary Sewers.—The population was assumed to be 100 persons per acre. The water consumption, and hence delivery to the sewer, was assumed to be 100 gallons per person per day. The maximum rate of delivery was taken to be 150 per cent. of the average rate of delivery. A further allowance of 0.003 cubic foot per second per acre was made to cover any infiltration into the sanitary sewers.

The smallest size of separate sanitary sewer planned was 8 inches and the largest size required was 72 inches. The other sizes planned were 10, 12, 15, 18, 20, 22, 24, 30, 36, 54 and 60-inch ones with the 15-inch and smaller sizes to flow half full and the larger sizes seven-tenths full. Gradients were determined upon that would produce velocities of not less than 2½ feet per second. The sanitary sewers were planned generally at the minimum grades because it

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was desired to minimize the amount of construction below the water-table.

As is well known, Long Island is the great North American Moraine of the glacial age. The backbone of Long Island—the ridge that extends from New York bay through Prospect park and adjacent to Eastern parkway—is the northern boundary of the drainage area and on its slope the soil is found to consist of boulders and other glacial drift, clay, hard-pan and loam.

The foot of the slope is located generally along East New York avenue, and from this avenue to the tidal marshes south of the Long Island railroad the soil consists of a stratum of loam overlying gravel and an excellent quality of sharp red building sand carrying water. The water-table has an elevation of about high water at the meadows and an elevation of about two feet above high water at the foot of the slope at East New York avenue.

South of the Long Island railroad, salt meadows and tidal marshes are found, the upper part of which consists of the usual salt-water grass growing in a stratum of swamp muck about four feet thick overlying a sharp red sand in which are occasional strata of intimately mixed pale red sand and clay forming an almost impervious substance. Occasionally salt-water holes may be encountered. These holes have mud depths in some instances of over twenty feet.

Subsequent to 1908 building operations along the slope adjacent to Eastern parkway caused renewed agitation for sewer construction which had been delayed because of the very great length of outlet required to drain a rather small area that required sewerage facilities at once. The opening proceedings for the streets and avenues in which the sewers would be constructed delayed the matter for years, owing to special legislation and court rulings being required to clarify the matter relating to one of the main avenues. However, and at length, the preliminary steps were taken and in due time the local boards and the Board of Estimate and Apportionment authorized the construction of the main lines of sewers and pumping-station in seven contracts. The titles of the work, dates and estimated cost are as follows:

(1) Sewers in Flatlands avenue from Ralph avenue to Paerdegat avenue north and thence southerly across the marginal area for water-front improvement between Flatlands avenue and Paerdegat basin, the substructures of the sewage pumping-station to be located within the marginal area for water-front improvement between Flatlands

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avenue and Paerdegat basin, and dredging a channel in Paerdegat basin. Authorized September 21, 1917. Estimated cost, $320,000.00.

(2) Sewers in Ralph avenue from Clarendon road to Avenue "D"; storm-water sewers in Ralph avenue from Avenue "D" to Paerdegat Avenue North and in Paerdegat Avenue North from Ralph avenue to Flatlands avenue, and sanitary sewers in Ralph avenue, east side, from Avenue "D" to Flatlands avenue. Authorized March 30, 1917. Estimated cost, $650,000.00.

(3) Sewers in Ralph avenue from Remsen avenue to Clarendon road. Authorized April 27, 1917. Estimated cost, $265,000.00.

(4) Sewers in Remsen avenue from Ralph avenue to and across East New York avenue, and in Utica avenue from East New York avenue to Carroll street. Authorized March 14, 1919. Estimated cost, $295,000.00.

(5) Sewers in Rutland road from Remsen avenue to Nostrand avenue, in Kingston avenue from Rutland road to Montgomery street, and in Midwood street from Kingston avenue to Nostrand avenue. Authorized April 11, 1919. Estimated cost, $265,000.00.

(6) Sewers in Lincoln road from Nostrand avenue to a point about 500 feet easterly of Nostrand avenue, in East New York Avenue from a point about 500 feet easterly of Nostrand avenue to Utica avenue, in New York avenue between East New York avenue and Midwood street, in Brooklyn avenue between East New York avenue and Midwood street, in Troy avenue between East New York avenue and Rutland road, and in Schenectady avenue between East New York avenue and Rutland road. Authorized December 19, 1919. Estimated cost, $94,000.00.

(7) Sewers in East 37th, East 38th, East 39th and East 40th Streets, each between Church and Snyder avenues, and outlet sewers in Snyder avenue between East 37th street and Ralph avenue. Authorized April 22, 1921. Estimated cost, $193,000.00.

Total estimated cost, including engineering and inspection, $2,082,000.00.

The approximate quantities for the first-mentioned contract include the following:

1 substructure of the sewage pumping-station,
1 outlet chamber for storm water,
262 linear feet of combined 186-inch, 168-inch and 90-inch storm-water sewer,
2 connecting chambers,

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209 linear feet of 186-inch storm-water sewer,
56 linear feet of 168-inch storm-water sewer,
39 linear feet of 90-inch storm-water sewer,
235 linear feet of 72-inch sanitary sewer,
156 linear feet of 54-inch sanitary sewer,
156 linear feet of 48-inch sanitary sewer,
60,000 cubic yards of dredging,
30,000 linear feet of bearing piles,
275,000 feet, board measure, of foundation planking and pile capping,
10 linear feet of 8-inch sanitary sewer,
100 linear feet of 24-inch by-pass,
2 drop manholes,
3 manholes,
1,000 pounds of anchor-rods,
90,000 pounds of additional steel bars,
10 cubic yards of additional concrete,
10 barrels of additional Portland cement.

The plans for the substructures of the sewage pumping-station, as modified, called for the construction below the finished street surface of plus eleven feet of

One high-level bar screen compartment 15 feet by 20 feet with a subgrade elevation of minus 10.1 feet,
One high-level wet well 35 feet by 20 feet with a subgrade elevation of minus 15 feet,
One high-level dry well 27 feet by 20 feet with a subgrade elevation of minus 15 feet,
One low-level bar screen compartment 16 feet by 20 feet with a subgrade elevation of minus 19.67 feet,
One low-level wet well 40 feet by 20 feet with a subgrade elevation of minus 23 feet,
One transformer room 27 feet by 40 feet, and one room for heating plant 32 feet by 20 feet, each with a subgrade elevation of minus one.
The substructures are of reinforced concrete, the exterior walls having a thickness of four feet below zero elevation and three feet above zero. The walls between the dry wells and wet wells have a thickness of four feet and the other interior walls are three feet thick.

The high-level wet well will receive the sanitary sewage intercepted from the combined sewers serving the area of 2,600 acres. The low-level well will receive the sanitary sewage from the whole of the Ralph Avenue area of 2,200 acres and from an area yet unmapped. The dry wells will be used for centrifugal pumps

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which will be connected by vertical shafts to electric motors to be installed under contracts not yet entered into.

The main storm-water outlet combining the 186-inch, 168-inch and 90-inch sewers is a reinforced-concrete structure of five connected chambers, each with a clear width of 11 feet 9 inches and a hight of 9 feet and a flat roof. The over-all width of the structure is 70 feet 9 inches. The five chambers terminate in an outlet whose over-all width at its portal is 84 feet, with ten openings each 9 feet high and 5 feet 4¾ inches wide. Owing to the uncertainty as to

SUBSTRUCTURES OF SEWAGE PUMPING-STATION, WITH 48-INCH SANITARY SEWAGE COLLECTOR UNDER CONSTRUCTION

the exact character of the soil, foundations of timber bearing piles, pile capping and foundation planking were specified to be placed if ordered.

The 186-inch storm-water sewer is a structure of reinforced concrete of an over-all width of 40 feet and a hight of 11 feet 11 inches, consisting of three sections, or barrels, each having an interior width of 11 feet 4 inches and a hight of 9 feet. The roofs are flat with curved fillets where junction is made with the supporting walls. This 186-inch sewer, provided for under this contract, extends only as far as the terminus of the old combined sewers at Ralph and

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In order to prevent the inrush of tide-water into the 48-inch sanitary collector two sets of tide-gates were planned to be placed in each of the three sections comprising the 186-inch sewer. Each gate consisted of two leaves 6 feet 3 inches wide by 8 feet 9 inches high of yellow-pine timber with bronze eye bolts, Tobin bronze binding rods and iron hinges.

The approximate quantities of the second-mentioned contract are as follows:

1,635 linear feet of 168-inch storm sewer,
425 linear feet of 156-inch storm sewer,
1,434 linear feet of 138-inch storm sewer,
1,171 linear feet of 138-inch combined sewer,
438 linear feet of 72-inch sanitary sewer,
3,192 linear feet of 54-inch sanitary sewer,
38 linear feet of 30-inch pipe sanitary sewer,
42 linear feet of 10-inch pipe sanitary sewer,
60 linear feet of 8-inch pipe sanitary sewer,
20 linear feet of 6-inch storm house-connection drain,
20 linear feet of 6-inch sanitary house-connection drain,
360 stand-pipes,
1 float chamber,
5 drop manholes,
17 manholes on storm sewers,
6 manholes on combined sewer,
12 manholes on sanitary sewers,
6 sewer basins,
800,000 feet, board measure, of foundation planking and pile capping,
200,000 feet, board measure, of sheeting and bracing,
100,000 linear feet of bearing piles,
20 cubic yards of additional concrete, Class "A",
10 cubic yards of additional concrete, Class "B",
10 barrels of additional Portland cement,
300,000 pounds of additional steel bars.

The 168-inch, 156-inch and 138-inch sewers are structures of two barrels each of reinforced concrete and dimensions as follows:

Sewer	Over-All	Each Barrel
168-inch.....	30 feet 10 inches by 10 feet 10 inches	8 feet by 13 feet 2 inches
156-inch.....	30 feet 6 inches by 10 feet 10 inches	8 feet by 13 feet
138-inch.....	22 feet by 10 feet 5 inches	8 feet by 8 feet 11 inches

Invert linings of specially selected brick or vitrified plates or blocks were called for.

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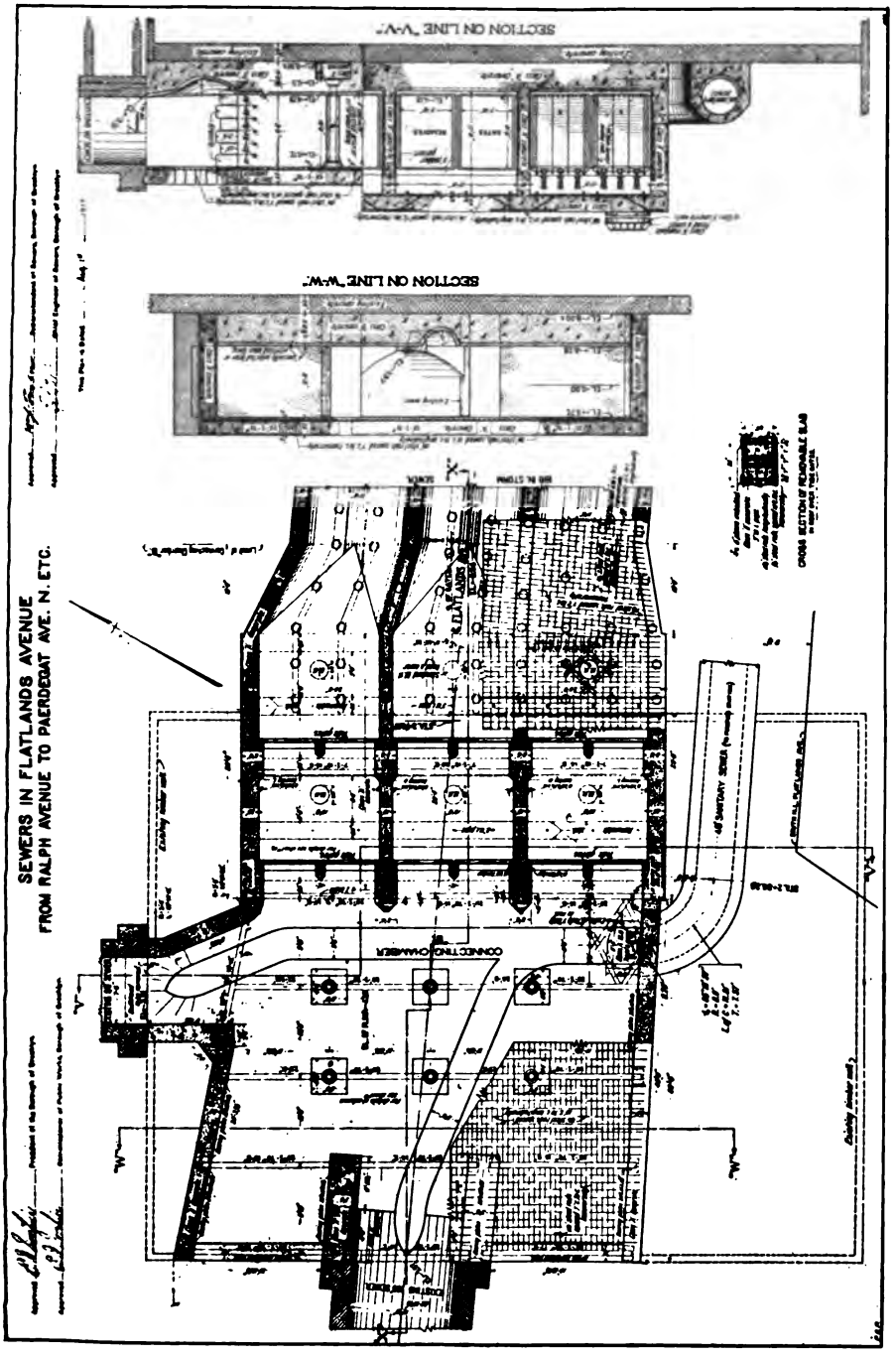

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The 72-inch and 54-inch sanitary sewers are of the same type as previously described. Provision was made for the placing, if required, of timber piles, pile capping and foundation planking. The stand-pipes were built to within approximately 12 feet of the street grades so that future connections from house-drains could readily and easily be made. The 30-inch, 10-inch and 8-inch pipe sanitary sewers are underflow connections for future extensions.

The storm sewer was continued to a point near Avenue "D", where the inner bottom elevation was zero. At this place diversion channels and a float and gate-chamber were planned.

A weir was called for adjacent to the diversion channels, the crest of the weir being placed at elevation plus two feet in order to prevent tidal water from entering the sanitary sewage collector.

The float and gate-chamber were arranged so that when the storm flow in the combined sewer reached a pre-determined hight, the floats would be actuated and would close the gate in the opening leading to the sanitary collector. The amount of flow that will be received by the sanitary collector is three times the normal dry-weather flow.

The approximate quantities of the third-mentioned contract include the following:

1,290 linear feet of 132-inch twin-section combined sewer,
728 linear feet of 132-inch single-section combined sewer,
675 linear feet of 126-inch combined sewer,
433 linear feet of 114-inch combined sewer,
400 linear feet of 6-inch house-connection drain,
550 linear feet of stand-pipes,
8 manholes,
1 drop manhole,
11 sewer basins,
250,000 feet, board measure, of foundation planking and pile capping,
170,000 feet, board measure, of sheeting and bracing,
3,000 linear feet of bearing piles,
5,000 pounds of additional steel bars,
10 cubic yards of masonry,
10 cubic yards of additional concrete, Class "A",
10 cubic yards of additional concrete, Class "B",
10 barrels of additional Portland cement.

The 132-inch twin-section sewer is a structure the over-all width of which is 21 feet 8 inches with an over-all hight of 10 feet

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7 inches. Each section has an interior width of 8 feet 9 inches and a hight of eight feet. It is of the same general form as the twin sewers of the second contract.

The 132-inch single-section sewer is a structure 11 feet in inside hight with a circular arch 15 feet in diameter. The contractor was given the option of building the arch of brick or reinforced concrete. Below the arch there is a vertical wall of plain concrete, two feet high, adjoining a gently sloping invert to be built of either specially selected brick or of vitrified stoneware plates. The 126-inch and 114-inch sewers are similar in form to the 132-inch single-section sewer.

Provision was made for placing piles, pile caps and foundation planking should conditions at the time of construction warrant such treatment. Steel reinforcement bars for the foundation slab were also specified to be placed if ordered.

The approximate quantities of the fourth contract include:

2,684 linear feet of 114-inch sewer,
713 linear feet of 108-inch sewer,
1,171 linear feet of 42-inch sewer,
134 linear feet of 30-inch sewer,
287 linear feet of 24-inch pipe sewer,
326 linear feet of 22-inch pipe sewer,
326 linear feet of 20-inch pipe sewer,
20 linear feet of 6-inch house-connection drain,
1,600 linear feet of stand-pipes,
27 manholes,
23 sewer basins,
60,000 feet, board measure, of foundation planking and pile capping,
200,000 feet, board measure, of sheeting and bracing,
1,000 linear feet of bearing piles,
10,000 pounds of additional steel bars,
10 cubic yards of additional concrete, Class "A",
100 cubic yards of additional concrete, Class "B",
10 cubic yards of additional brick masonry,
10 barrels of additional Portland cement,
1,000 cubic yards of embankment.

The 114-inch and 108-inch sewers were of similar shape to the single-section sewers of the third contract. The same options and provisions were specified. The 42-inch and 30-inch sewers were egg-shaped brick structures without any spread foundation.

The pipe sewers were specified to be built of vitrified stoneware pipe or cement concrete machine-made pipe. The specifications of

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the Brooklyn Bureau of Sewers for the past fifteen years have permitted the use of either material, but only vitrified pipe has been offered.

The line of this contract ran through very open country in which sand-pits had been dug. Sand had been removed until the water-table was ecountered and in one instance the bottom of a large sand-pit lay below the subgrade of the sewer. At that location a slab of concrete some two feet thick was planned to be laid on the sand-pit bottom as a foundation for the sewer.

The approximate quantities of the fifth contract include:

385 linear feet of 102-inch sewer,
1,360 linear feet of 96-inch sewer,
534 linear feet of 90-inch sewer,
719 linear feet of 78-inch sewer,
781 linear feet of 72-inch sewer,
1,020 linear feet of 48-inch sewer,
659 linear feet of 42-inch sewer,
530 linear feet of 36-inch sewer,
279 linear feet of 30-inch sewer,
1,577 linear feet of 24-inch pipe sewer,
630 linear feet of 18-inch pipe sewer,
1,361 linear feet of 12-inch pipe sewer,
20 linear feet of 8-inch house-connection drain,
2,700 linear feet of 6-inch house-connection drain,
1,000 linear feet of stand-pipes,
59 manholes,
51 sewer basins,
4 sewer basins reconnected,
50,000 feet, board measure, of foundation planking and pile capping,
200,000 feet, board measure, of sheeting and bracing,
1,000 pounds of additional steel bars,
10 cubic yards of additional concrete, Class "A",
10 cubic yards of additional concrete, Class "B",
100 cubic yards of concrete, Class "B", below subgrade,
10 cubic yards of brick masonry,
10 barrels of additional Portland cement,
100 cubic yards of extra excavation,
1,000 linear feet of concrete piles.

The 102-inch, 96-inch and 90-inch sewers were of special shapes similar to those heretofore mentioned. Similar options as to lining and arches were given the contractor. The 78-inch and 72-inch sewers were circular, of plain concrete below the springing-line, lined

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with either specially selected brick or vitrified stoneware lining plates or blocks. An option was given the contractor to build the arches of either brick or reinforced concrete. The 48-inch to 30-inch sewers were egg-shaped and an option was given the contractor to construct these sewers of either brick, brick and concrete, or of

COMPLETED INVERT OF 48-INCH EGG-SHAPED SEGMENTAL BLOCK SEWER

vitrified segmental blocks. The sewers 24 inches and less in diameter were of pipe with an option of furnishing either vitrified stoneware or cement concrete.

The sixth and seventh contracts were for smaller sums of money but were for considerable mileage of sewers 54 inches and under.

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The approximate quantities are:

Sixth Contract

268 linear feet of 48-inch sewer,
750 linear feet of 42-inch sewer,
1,591 linear feet of 36-inch sewer,
54 linear feet of 30-inch sewer,
118 linear feet of 24-inch pipe sewer,
280 linear feet of 18-inch pipe sewer,
260 linear feet of 15-inch pipe sewer,
5,368 linear feet of 12-inch pipe sewer,
3,840 linear feet of 6-inch house-connection drain,
77 manholes,
32 sewer basins,
17,000 feet, board measure, of foundation planking,
1,000 feet, board measure, of sheeting and bracing,
5 cubic yards of additional concrete, Class "A".

Seventh Contract

1,587 linear feet of 54-inch sewer,
1,883 linear feet of 48-inch sewer,
1,077 linear feet of 42-inch sewer,
847 linear feet of 36-inch sewer,
255 linear feet of 30-inch sewer,
272 linear feet of 24-inch pipe sewer,
260 linear feet of 20-inch pipe sewer,
2,011 linear feet of 12-inch pipe sewer,
1,855 linear feet of 6-inch house-connection drain,
48 manholes,
52 sewer basins,
42,000 feet, board measure, of foundation planking,
6,000 feet, board measure, of sheeting and bracing,
5 cubic yards of additional concrete, Class "B".

Options were given to construct the 30-inch to 54-inch sewers of the last two mentioned contracts of either brick, brick and concrete, or of vitrified stoneware segmental block. The pipe sewers, as in the other contracts, were to be of either vitrified stoneware or cement concrete.

The sewer contracts were let at different times and not in the order of the numbers of the sections. The contractors who were the lowest bidders, dates of opening bids and executing contract and amounts for which contracts were awarded are as follows:

(1) Flatlands avenue, from Ralph avenue to Paerdegat Avenue North, etc. Bids received October 17, 1917. John

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F. Cogan Company, Contractors. Date of contract, November 5, 1917. Amount, $432,265.00.

(2) Ralph avenue from Clarendon road to Avenue "D", etc. Bids received May 16, 1917. John F. Cogan Company, Contractors. Date of contract, June 5, 1917. Amount, $700,238.84.

(3) Ralph avenue, from Remsen avenue to Clarendon road. Bids received June 7, 1917. John F. Cogan Company, Contractors. Date of contract, June 25, 1917. Amount, $227,529.75.

(4) Remsen avenue, etc. Bids received April 2, 1919. Louis Kalischer, Contractor (assigned to Necaro Company). Date of contract, May 1, 1919. Amount, $219,628.15.

(5) Rutland road, etc. Bids received May 7, 1919. Rosenthal Engineering and Contracting Company, Contractor. Date of contract, June 11, 1919. Amount, $240,013.19.

(6) Lincoln road, etc. Bids received January 28, 1920. James O'Leary, Contractor. Date of contract, March 8, 1920. Amount, $82,615.55.

(7) East 37th street, etc. Bids received May 25, 1921. P. J. Donlon Contracting Company, Contractor. Date of contract, June 22, 1921. Amount, $124,125.00.

The total sum for the seven contracts was $2,026,415.48 as compared with an estimated cost of $2,082,000.00, which latter sum included engineering and inspection. The total length of sewer construction was over 45,000 feet, or more than 8.55 miles.

Bids were received for the second-mentioned contract on May 16, 1917, about a month after Congress had declared that a state of war existed between the United States and the German Empire. As will be remembered, economic and financial conditions were upset and contractors who entered into obligations assumed heavy hazards. The bids received were in excess of the estimated cost, but as it was considered that the improvement was one which had been awaited for ten years and in view of the fact that there was no assurance that a re-letting would yield lower prices, the work was awarded to the lowest bidder.

The bids for the third contract were received on June 7, 1917, the lowest bid being for 85 per cent. of the engineer's estimate. This bid was made by the successful bidder on the previously let contract, who was undoubtedly in the most strategic position as to costs of operation.

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The next contract let was for Contract No. 1, the outlet section. Bids were received on October 17, 1917, and again the John F. Cogan Company, Contractors, was the lowest bidder.

It was in connection with the construction of the work of these three contracts that the most interesting and difficult work of the entire system was performed, and hence the major part of the remainder of this paper will be devoted to them. The fact that one contracting company was the lowest bidder on three connecting jobs of such magnitude minimized the many difficulties that arise when several contracts, adjacent to each other, for the construction of sewers in water-bearing ground, are in operation at the same time.

The contracting concern was one of large experience in the construction of sewers, as well as in dams and reservoirs, and was provided with ample equipment and large financial resources and possessed unusual skill in handling difficult and hazardous undertakings. The contractor's operation of the work of the three contracts is worthy of more than passing note, because of the great danger that always attends the construction of sewers in open cut below water.

The contractor began operations by starting work on the second contract at a point near the Long Island railroad and working both ways. The location of the railroad near the upper part of the middle contract was taken advantage of by the contractor who established a storage and working yard adjacent to a siding built for him by the railroad. The railroad at Ralph avenue is elevated and from the elevated position delivery was made to the storage yard of the contractor of broken stone, gravel, lumber, cement, steel and other materials required.

The sand encountered in the excavations was, as heretofore mentioned, of an excellent quality and was used in the making of mortar and concrete. The contractor established in his yard a central concrete mixing plant. All of the concrete used in the three contracts was made at this central mixing plant, which consisted of a 40-horse-power steam boiler, a steam engine, a pump, a one-yard Municipal (Chicago) concrete mixer, storage tanks and bins and a derrick equipped with a clam-shell bucket. Water for concrete and other purposes was obtained by pumping it from the vast supply in the sands below the water-table.

Water was encountered in the trenches at the beginning of operations. At the location where the 54-inch intercepting sanitary collector made connection with the combined sewer, the subgrade of

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a channel alongside about two feet wide which was used for the conveyance of ground-water to the pumping equipment mounted in a movable plant, which was always maintained a considerable distance ahead of the location where the sewer was being constructed.

The sides of the upper part of the trench were permitted to slope to their angle of repose and the lower portion was sheeted with 2-inch timber eight feet in length, extending about two feet below the bottom of the trench.

The trench for the sanitary sewer and ground-water channel was excavated with a ¾-yard clam-shell bucket suspended from the end of the 50-foot boom of a traveling derrick, which was installed on a track laid on the surface of the ground as left by the steam-shovel and operated by a 50-horse-power electric hoist. The trench for the sanitary sewer was close-sheeted, but the sheeting was not watertight. The bottom throughout the entire length of the work was of an excellent character and furnished a stable and unyielding foundation. While it had been believed that soft pockets might be encountered, making necessary the use of pile foundations, which had been specified to be placed, if ordered, no piles were placed, excepting at the pumping-station and under a sanitary sewer and by-pass where the foundation had been disturbed during the construction of adjacent work.

As has been previously stated, the land south of the Long Island railroad was low lying and marshy. The contractor in order to minimize the danger of damage from tidal water entering the trenches, used a considerable quantity of excavation spoil in the formation of a dike completely about the entire work.

The contractor installed a narrow-gage 60-pound railroad alongside his work and furnished it with side dumping cars of three yards capacity each and four 3-ton and one 6-ton gasoline-engine locomotives. The steam-shovel delivered the excavated material to the dump-cars which were hauled by the 6-ton locomotive to the desired location for either back-fill, construction of dikes or spoil-bank. The smaller locomotives were used for disposing of the excavation from the clam-shell bucket and for conveying concrete.

The sheeting was driven by the aid of a compressed-air hammer (McKiernan-Terry). In dry ground a water jet was employed to accelerate the driving, and in wet ground a compressed-air jet was similarly employed.

Pumping was continued throughout the 24 hours of each day

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and at no time did any serious delay occur because of lack of pumping capacity or break-down.

The volume of water removed was amazingly large, the capacities of the pumps being approximately as follows: 10-inch pump, 3,000 gallons per minute; 8-inch pump, 1,920 gallons per minute; and 6-inch pump, 1,080 gallons per minute.

A really remarkable and highly interesting feature of the work was the entire absence of water at the location where concreting was in progress. Many visitors to the work commented upon the absence of water from the trenches and really failed to appreciate the vast volume that was being removed by the pumps. The contractor actually pumped the country dry of ground-water below the level of sewer construction and kept it dry by continued pumping, thereby facilitating progress and safeguarding the work in its incompleted state.

The bottom of the trench for the sanitary sewer and water channel was carefully trimmed and covered with two layers of 2-inch planking, upon which the forms for the sanitary sewer were erected. The planking was extended to cover the bottom of the ground-water channel in order to obviate the danger which might result from flowing water undercutting the work.

A few feet in advance of the end of each section of approximately 50 feet of finished sanitary sewer the contractor erected transverse bulkheads extending clear across the entire width of the trench excavation and below the level of the sewer bottom. Behind this bulkhead the contractor deposited gravel mixed with a liberal quantity of salt grass or hay. In this bulkhead and in line with the water channel a pipe was built, through which the ground-water accumulating adjacent to the finished sewer section flowed into the channel where construction operations were still in progress. These bulkheads prevented any wash from under the completed sections and greatly facilitated operations. The pipes in the bulkheads were filled in with concrete when the construction work had advanced sufficiently far to permit such action.

Concrete was delivered to the work in side-dump cars made of steel and chuted down into the trench inside the forms and up to the springing-line of the arch. After the concrete in the invert had set, the lining of specially selected brick was laid, after which forms, both for inside and outside of arch, were set. Concrete was placed in these forms from the dump-cars and after the lapse of 48 hours

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the forms, which were of the Blaw metal type, were collapsed and moved forward for a repetition of the operations.

The sanitary sewer was laid in sections of 40 feet and the usual rate of progress was 120 feet per week.

The mixing, conveying and placing of the concrete was a matter of vital importance. The quantities of cement and aggregate were carefully measured for each batch and just enough water was added to produce a concrete that would settle into place without spading. Surplus water would produce a more porous concrete and as the exclusion of ground-water from the sanitary sewer was imperative, the greatest care was observed in the preparation and placing of the concrete. It is very gratifying to note that when the entire work was completed and an inspection and test made of the sanitary sewer the amount of leakage through the sewers, manholes and standpipes was 5¼ gallons per minute.

Four thousand feet of 54-inch and 72-inch sanitary sewer were tested. The subgrade of the sewer lay at its upper end at a depth of about five feet and at its lower end at a depth of about 18 feet below the water-table. The sanitary sewer was always completed well ahead of the storm sewer construction, never less than 20 feet and sometimes 200 feet.

When the sanitary sewer had been completed in advance of the storm sewer a trestle or bridge of timbers was built ahead and at the level of the top of the completed storm sewer and on this bridge were laid narrow-gage tracks, upon which were run the side-dumping cars conveying the concrete. The track was laid about the middle longitudinal line of the storm sewers, making easy the placing of concrete by means of an open chute at any place desired. A turntable near the mixing plant enabled the contractor to turn the dumping side of the cars to face whichever side of the trench concrete placing was required.

The concrete for the invert of the storm sewer was placed inside of timber forms made to correspond to the required shape. The wooden forms were made of ribs, spaced six feet apart, to the under side of which were nailed lagging pieces. The forms were provided with openings, through which the concrete was poured. The end of each section, 20 feet in length, was bulkheaded. Boxes were attached to the bulkheads so that recesses would be formed for bonding the concrete of the next section. The concrete invert was allowed to set for 48 hours after which the invert forms were removed and collapsible Blaw steel forms were placed for the walls and roofs.

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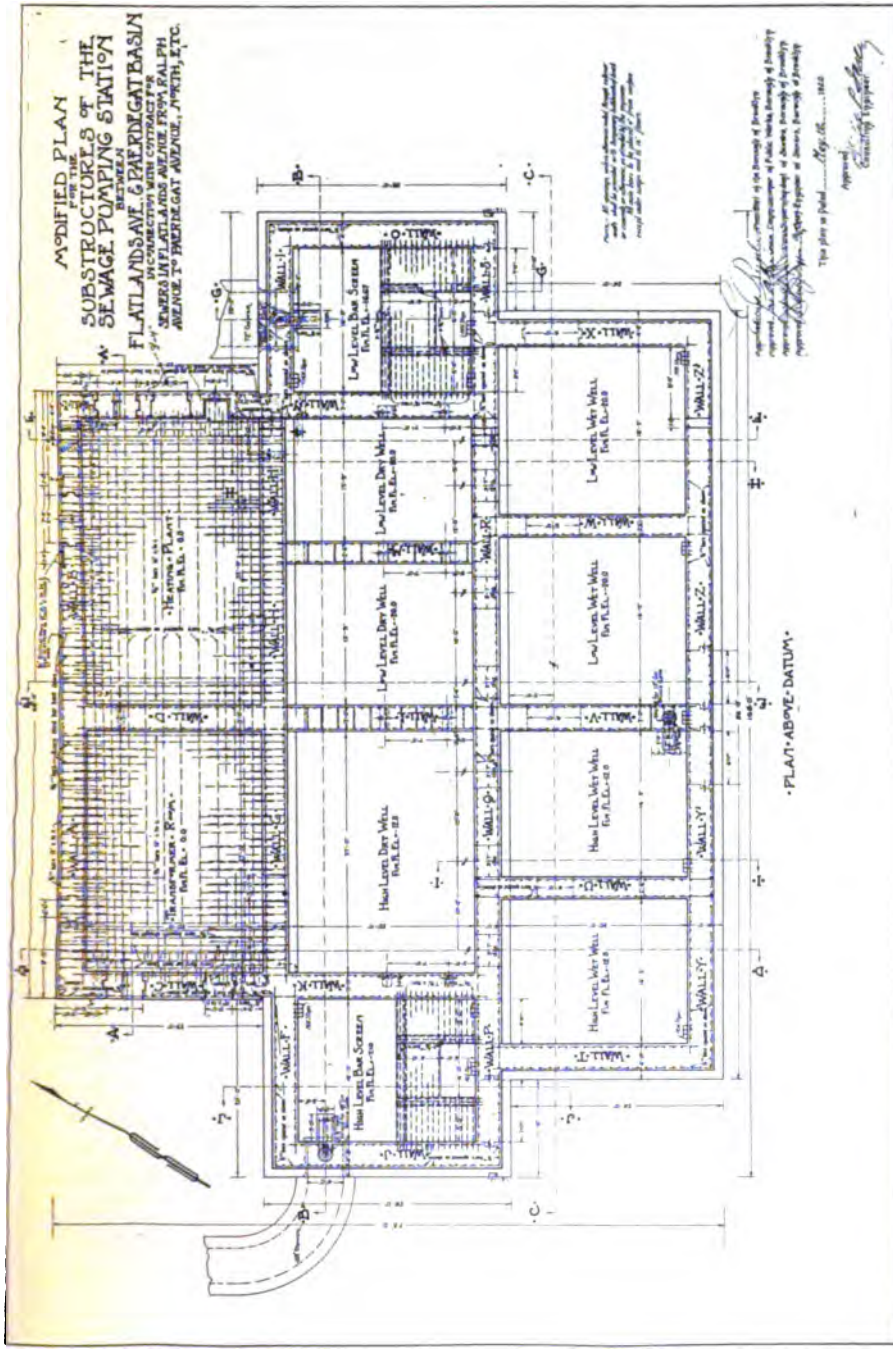

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Steel reinforcement bars were laid as specified in chairs made for the purpose. The trestle upon which was laid the rails carrying the cars delivering the concrete was removed and the rails relaid above the concrete forms and extended beyond to the trestle so that concrete could be delivered to the roof and walls as well as at the invert. The concrete for the walls and roof was laid at the same time and a rate of progress maintained of 20 feet per day—about the same as for the sanitary sewer.

The operations on that portion of the work which lay north of the railroad were substantially the same with the pumping requirements very much less and ceasing altogether near the beginning of the third contract at Clarendon road.

Back-filling to the required hight of embankment was made directly from the dump-cars which conveyed the earth fill from the excavations or spoil-banks.

The invert lining was not laid until a considerable time after the remainder of the sewer had been completed. The lining used by the contractor in the second and third contracts was specially selected brick. Brick rose in price during the progress of the first contract and became difficult to get and hence the contractor used vitrified stoneware plates. At manhole openings, brick lining was required because of the possibility of damage to the plates by the fall of substances. The vitrified stoneware plates undoubtedly furnish the smoother lining, but the bricks are less brittle. It will be determined as time goes on which of the lining surfaces is the better and more economical.

The third contract moved with expedition and no untoward occurrences, nearly the whole work lying above the water-table. The second contract moved southerly toward the outlet section, also with expedition.

The embankment over the finished storm sewer of the second contract was used by the contractor as a roadway for the third contract, which contract was not begun until the second was nearly completed.

As stated earlier, the work of the first contract lay near the head of Paerdegat basin and included the most hazardous operations of the entire system.

The storm sewers, the sanitary sewers, the by-pass from the high-level sanitary sewer to the low-level sanitary sewer while at lower elevations than in the stretches farther above in the system, were

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constructed with seemingly as little difficulty as was experienced elsewhere in the work.

The chamber in which connection was made from the old combined sewers to the storm sewer, together with diversion to a sanitary collector, was built in much the same manner as the twin storm sewers of the second contract; but the substructures, the lowest level of which was 24 feet below mean high water, gave the contractor the opportunity for the exercise of an unusual type of skill and ingenuity. A dike was constructed about the site of all the work of the first contract and excavation was made by the steam shovel down to elevation minus nine, or about ten feet below mean high water. The pumping equipment of one 10-inch, one 8-inch and two 6-inch pumps was mounted on a platform at one side of the excavation and as the volume of water to be cared for increased, the number of pumps operating constantly was also increased until the entire equipment was at work with the exception of an idle standby kept for emergency purposes.

The ground level at minus nine feet was dry during the construction. The sides of the large area excavated by the steam-shovel were sloped to their natural angle of repose. Below the level of minus nine feet excavation for the several chambers of lower depths was made with the clam-shell bucket. The sides of all such excavations were sheeted with commercial 2-inch planking braced by dimensioned timber of varying sizes, generally 8 inches by 8 inches, 8 inches by 10 inches and 10 inches by 10 inches.

The excavation that was made extended approximately three feet outside of the neat section of the work. Adjacent to the low-level wet well an additional excavation was made and used as a sump in which the pumping equipment was located. Water that entered through the joints of the sheeting planks ran in the 3-foot space reserved for it to the sump.

The excavations for the low-level wells were continued to approximately elevation minus 25 feet, about 24 inches below the bottom of the finished well. A layer of gravel about 18 inches thick was spread over the bottom of this excavation.

The gravel acted as a strainer for the ground-water which flowed through the gravel without moving it or without producing any movement in the sand. In fact, the gravel acted as a foundation stabilizer and undoubtedly prevented "boilers" from creating an unstable bottom.

After the gravel had been leveled, two decks of 2-inch timber

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planking were laid thereon and on this timber flooring the concrete was laid. Reinforcement bars for the bottom slab were arranged as planned and set on chairs devised for the purpose.

The concrete for the bottom of each compartment was laid in continuous operations. During this period the central concrete mixing plant produced an average of one batch every four minutes and maintained that rate without interruption for ten hours.

Before the concrete in the floors had come to initial set the reinforcement bars for the walls were set in vertical position in the concrete bottom, which was then allowed to set. At no time were walls built before the expiration of ten days from the time that the concrete for the bottom was placed. The walls surrounding the low-level wells were built in sections.

Bearing piles were driven for the foundations of all the other chambers of the substructures. Gravel was spread over the bottom of the excavations for the low-level bar screen well, high-level wet well, high-level dry well and high-level bar screen compartment to stiffen and stabilize them. No gravel was spread on the bottom of the excavation for the transformer room and room for the heating plant, the elevation of the bottom of these rooms being minus one.

The timber tide-gates were built by the contractor substantially as shown on the design. They operate satisfactorily and it is believed that the success of their operation will warrant the revision of the drainage plan for several areas in Brooklyn where sewers of the separate system were contemplated. Low-lying territories adjacent to Jamaica bay do not lend themselves very readily to combined systems, but areas lying generally above elevation 15 feet may be supplied with combined sewers which can be continued behind tide-gates close to sewage pumping-stations where the domestic flow can be intercepted, conveyed to the stations and subjected to such treatment as will render the sewage unobjectionable to the senses. A decade or so ago the trend of engineering thought and practice for areas such as lie on the south shore of Long Island was toward entirely separate systems of storm drains and sanitary sewers.

Several such systems have been installed in Brooklyn in the last decade and the experience there gained is such as to compel extreme caution in the installation of similar systems.

Entirely separate systems frequently extend into ground of high level. The construction of separate house-connection drains and two sets of drain pipes in each house are always required where such sewers are built. As the ordinances require that these drain pipes

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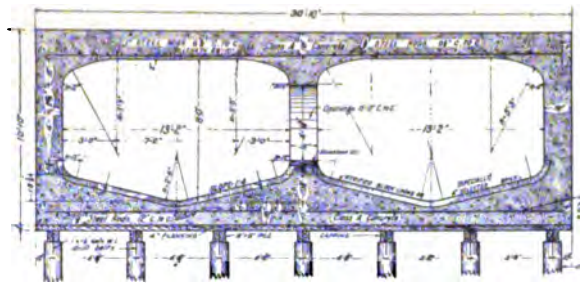
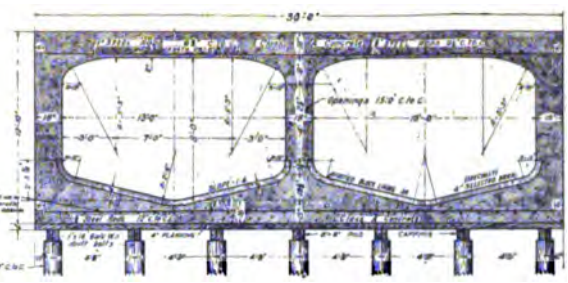
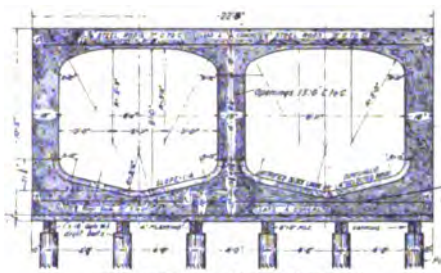
SEWERS IN RALPH AVENUE, FROM CLARENDON ROAD TO AVENUE D, ETC



CROSS SECTION OF 168 INCH STORM SEWER.

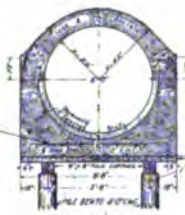


CROSS SECTION OF 156 INCH STORM SEWER.



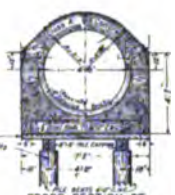
CROSS SECTION OF 138 INCH STORM SEWER AND 138 INCH COMBINED SEWER.

Wherever vitrified block lining, as shown on the plans, is used the block lining shall be similar to the sample in the Office of the Chief Engineer of Sewers. Whether the quality of the sewers are of specially selected brick or of vitrified block lining, the distance from the manhole on sewer to the intersection shall be 16 inches.

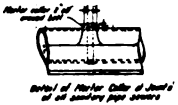


CROSS SECTION OF 72 INCH SANITARY SEWER.

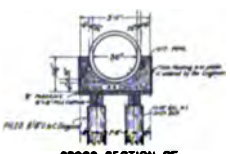
no piles, nor pile capping nor foundation planking shall be placed unless ordered by the Engineer see addenda



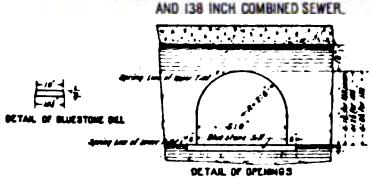
CROSS SECTION OF 54 INCH SANITARY SEWER.



Detail of Mortar Collar at Joints of all sanitary pipe sewers



CROSS SECTION OF 30 INCH SANITARY SEWER



DETAIL OF BLUESTONE SILL

DETAIL OF OPENINGS

CROSS SECTION OF 10 INCH SANITARY SEWER

CROSS SECTION OF 8 INCH SANITARY SEWER

ALTERNATIVE FOUNDATION ON 10 AND 8 INCH PIPE SEWERS

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be of cast iron, the cost of the additional work, disregarding the cost of the sanitary system entirely, is usually more than $100 for each house. When to this amount is added the cost of the sanitary sewers, the additional burden upon the property reaches an alarming amount.

The installation, therefore, of a combined system with tide-gates, storm outlets and sanitary interceptors gives rise to the hope that much money will be saved in spite of the increase in cost of pumping during the times of rain before the control devices shut off the flow into the sanitary interceptors.

The last work completed on the first contract was the dredging of the outfall channel in Paerdegat basin. This channel was dredged by a sub-contractor, who cut his way in from Jamaica bay. The specifications required a channel 35 feet wide at the bottom with sides sloped to their natural angle of repose, with a bottom elevation of minus seven feet. The sub-contractor used a grab bucket dredge mounted on floating equipment and deposited the excavated material in banks adjacent to the work. It was found impracticable to operate the dredge economically in less than six feet depth at low water, which corresponds to an elevation of minus nine feet; a channel of greater depth than was anticipated has therefore been obtained, but this is not to be deplored. Allowances for over depth dredging, not exceeding one foot, were allowed the contractor. This is standard practice in United States Government contracts, as well as in municipal contracts.

It may be interesting to note that the assessment for the entire work was levied substantially at the time that the last of the earlier authorized contracts was completed. The rates vary with the degree of benefit, those parcels of land lying contiguous to the actual sewers being assessed at the higher rate for complete benefit; those lying away from the lines of the work being assessed at a rate depending on how much sewer construction is necessary before complete benefit may be enjoyed.

Studies of all tributary areas with estimates of cost were furnished the Board of Assessors who determined the amounts to be paid. The rate of assessment for complete benefit was 12 cents per square foot or $240 for a plot with 20-foot front by 100 feet in depth. An additional assessment of probably $10 for each 20-foot by 100-foot lot will be made later when the superstructures together with mechanical equipment and treatment plant have been constructed.

Preliminary authorizations were given for the above by the Board of Estimate and Apportionment on July 8, 1921, as follows:

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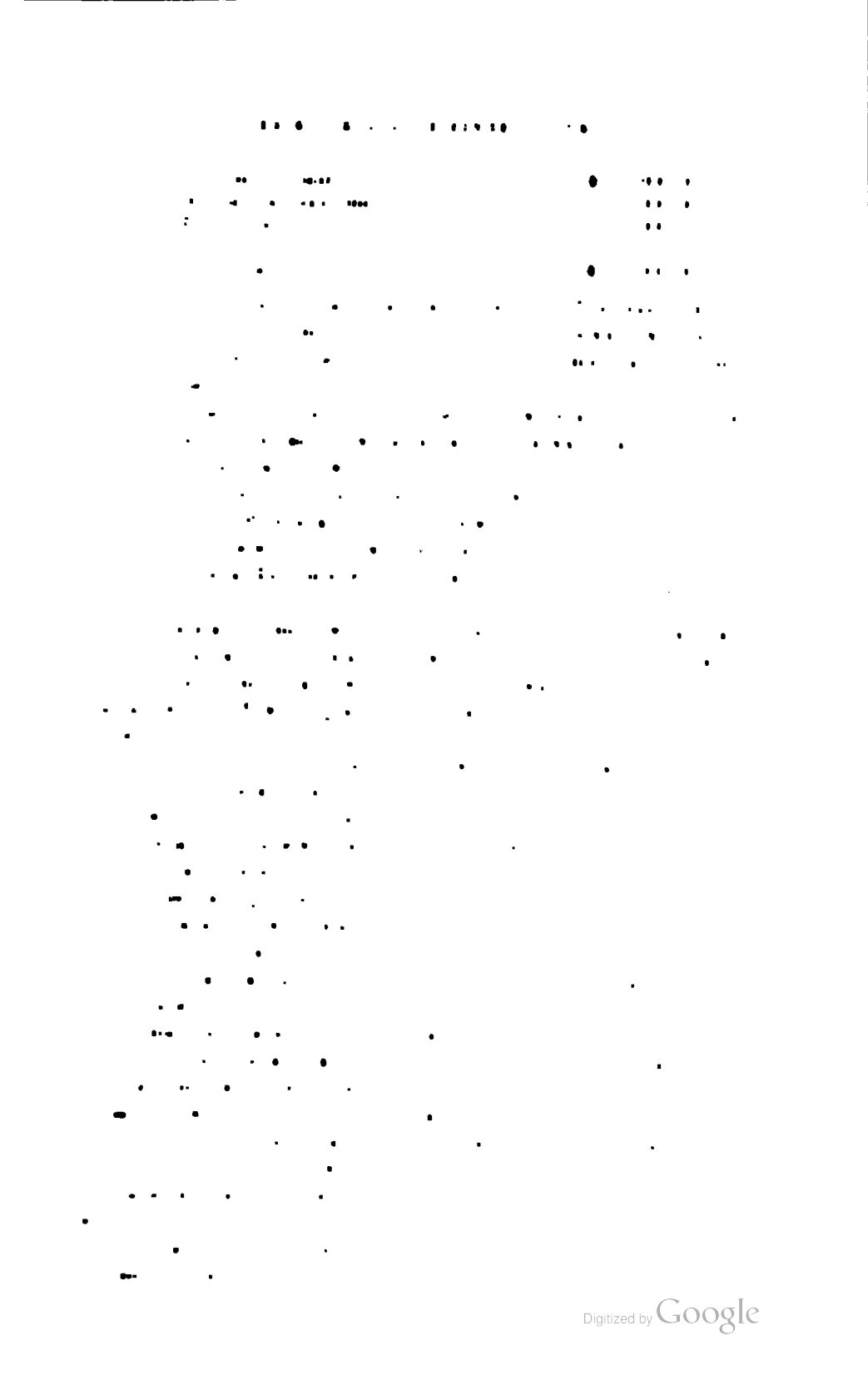

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The accompanying plates and drawings illustrate the details of the designs, the equipment and method of operation of the contractors, and the work in progress, as well as when completed.

The original studies were begun in the administration of Borough President Bird S. Coler and the authorizations for the first three contracts were obtained during the administration of Borough Presidents Alfred E. Steers and Lewis H. Pounds. The last four contracts were authorized during the present administration of Borough President Edward Riegelmann and Consulting Engineer Philip P. Farley, M.M.E.N.Y., and the major part of the construction work was performed during this administration.

The designs and plans were made under the direction of Edwin J. Fort, Chief Engineer of the Bureau of Sewers from 1907 to 1918, when he resigned to become City Manager of Niagara Falls, N. Y., and under the direction since 1918 of Arthur J. Griffin, who became Chief Engineer after Mr. Fort resigned. The Engineer of Design was George T. Hammond, M.M.E.N.Y., who since his return from the Public Health Service during the war, has been engaged upon special problems relating to sewage purification and disposal. The author has been in general charge and has had direct supervision of the preparation of designs, plans, specifications and contracts for the entire work.

The construction work was performed under the supervision of Mr. Griffin, who had been Engineer of Construction until 1918, and since that time under the supervision of John H. Vogt, Engineer of Construction.

The engineers resident on the work were I. H. Kirby, M.M.E.N.Y., for the first three contracts and Henry J. Lynch for the remaining four contracts.

Discussion

NORMAN B. GARDINER.*—This very interesting paper has brought forward many problems. One very interesting feature is the tide-gates. The speaker would like very much to know how well they work and whether they are obstructed at all by floating matter. We propose, or are considering the use of tide-gates in Manhattan for the same purpose they have been used in Brooklyn, but we are still in doubt whether they would operate satisfactorily and were considering the installation of a trial tide-gate before deciding.

* Assistant Engineer, Engineering Division, Office of President of Borough of Manhattan.

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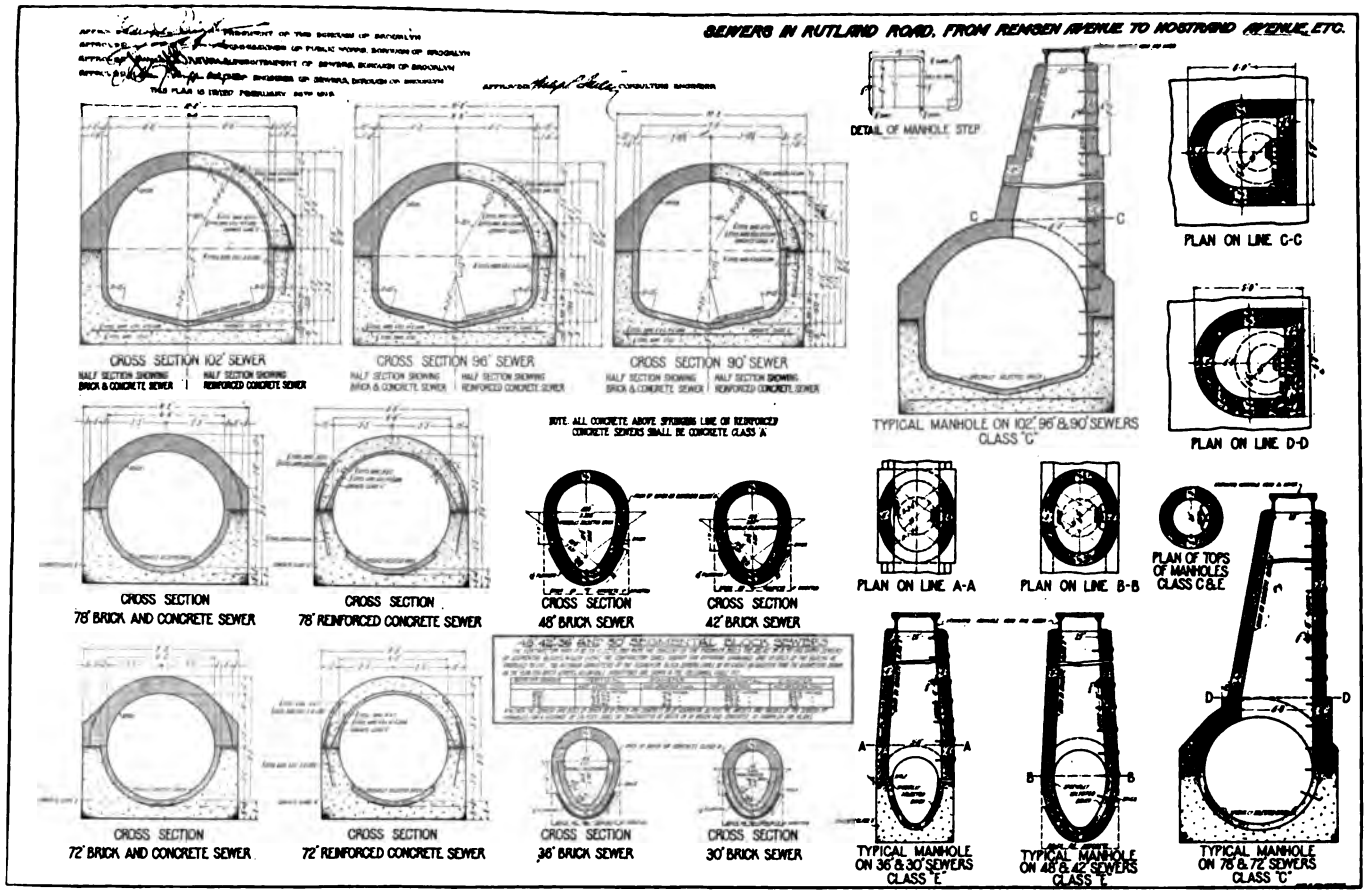
SEWERS IN RUTLAND ROAD, FROM REMSEN AVENUE TO NOSTRAND AVENUE, ETC.
CROSS SECTION 102' SEWER
HALF SECTION SHOWING BRICK & CONCRETE SEWER
HALF SECTION SHOWING REINFORCED CONCRETE SEWER
CROSS SECTION 96' SEWER
CROSS SECTION 90' SEWER
DETAIL OF MANHOLE STEP
TYPICAL MANHOLE ON 102', 96' & 90' SEWERS CLASS 'C'
PLAN ON LINE C-C
PLAN ON LINE D-D
NOTE. ALL CONCRETE ABOVE SPRINGING LINE OR REINFORCED CONCRETE SEWERS SHALL BE CONCRETE CLASS A
CROSS SECTION 78' BRICK AND CONCRETE SEWER
CROSS SECTION 78' REINFORCED CONCRETE SEWER
CROSS SECTION 48' BRICK SEWER
CROSS SECTION 42' BRICK SEWER
PLAN ON LINE A-A
PLAN ON LINE B-B
PLAN OF TOPS OF MANHOLES CLASS C & E
CROSS SECTION 72' BRICK AND CONCRETE SEWER
CROSS SECTION 72' REINFORCED CONCRETE SEWER
CROSS SECTION 36' BRICK SEWER
CROSS SECTION 30' BRICK SEWER
TYPICAL MANHOLE ON 36' & 30' SEWERS CLASS 'E'
TYPICAL MANHOLE ON 48' & 42' SEWERS CLASS 'E'
TYPICAL MANHOLE ON 78' & 72' SEWERS CLASS 'C'

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If they could be used in Manhattan, the existing combined system of sewers could remain and it would be unnecessary to build a separate system of sewers in order that the sewage might be treated. It would simply be necessary to build intercepting sewers into which the dry-weather flow could be diverted by dams, or weirs, in that portion of the sewerage system above tidal influence, and in that portion of the system affected by tides the sewage would be conducted into the intercepting sewers by conductors of limited capacity.

If a tide-gate could be designed which would function satisfactorily —and the speaker believes it can, if indeed it has not already been accomplished—it will readily be seen what a saving could be effected by its use.

Another question which the speaker would like to have answered is about the segmental blocks. Do you find that the segmental blocks are warped and did they give a really true and smooth invert? In Manhattan our experience with them has not been very satisfactory. We seemed to be unable to get them free of warp. As a result it was impossible to get a true and smooth invert. We also had difficulty in constructing a 3-foot circular sewer with them. The invert, up to the springing line, was laid in a concrete cradle, but even then the arch distorted when the form was removed to let the blocks settle into position and the joints opened by this distortion had to be pointed.

It may be interesting also, in connection with the question of run-off, to state that we have had some discussion recently with the Board of Estimate and Apportionment as to the percentage of run-off to be used in calculating the sizes of our sewers. We are using the New York curve formula $\frac{150}{t+20}$ and a run-off of 60 per cent. This formula is designed to represent the rates of rainfall which would occur once in ten years and includes four minutes entry time in the factor 20.

The Board of Estimate and Apportionment wanted us to use a larger percentage for the run-off. This we objected to, as we had found that, using the formula mentioned with a 60-per-cent. run-off, some of our largest sewers when computed showed they were inadequate; in fact, the hydraulic grade line reached the street level in many instances, and yet, even in some of the heaviest storms that have occurred during the last 50 years, notably the storms which occurred in 1913, they have given no trouble.

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tion of the "McMath" formula and with the judgment we have learned to exercise arrive at a result; we could then take the "Rational" formula and with small warrantable alterations of the factors of imperviousness or run-off, or perhaps the time of concentration, reach almost the identical conclusion that was reached with the "McMath" formula. Now what does this show? Nothing conclusive. The author would like to emphasize the matter which was taken up with the Board of Directors of The Municipal Engineers not long ago concerning the necessity—the imperative necessity—for the City of New York to undertake and determine once and for all what are the real conditions here so far as run-off is concerned, and that, by the installation of water stage registers in our sewers, together with rain gages in every locality in the City of New York. Then, and then only, will this discussion cease, because until that is done, one opinion might be just as good as another and neither would be founded on anything very definite. We believe from our experience that in the Classon Avenue system of storm relief sewers, we have a system that will do what we thought it would do, and that is to take care of rain-storms in which a rate of three inches per hour is maintained for 30 minutes.

The records of the Brooklyn Bureau of Sewers indicate that storms of such severity occur on an average once in ten years. A recent article by John W. Alvord, Chief Engineer, Department of Labor, Washington, D. C., appearing in the United States Monthly Weather Review of August, 1921, contains graphs showing the relation between frequency and intensity of rainfall for storms of various durations. The graph for New York indicates that a storm in which the rate of three inches per hour will be maintained for 30 minutes may be expected every 8½ years.

The Classon Avenue storm relief sewers have been operated very well. We feel satisfied that so far as large areas are concerned we are not far from the correct values in our determinations. With the smaller areas we are somewhat doubtful.

The rainfall curve that the preceding speaker speaks of, namely $i = \frac{150}{t + 20}$ is precisely what has been developed and used in Brooklyn. The author believes, however, that the denominator $t + 20$ used by Manhattan is made up of $t + 16$ plus an entrance time of four minutes. The Brooklyn 10-year curve is really $i = \frac{150}{t + 20}$

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and the Manhattan 10-year curve is $i = \frac{150}{t+16}$. In the usual application of the "Rational" formula it has been the practice to increase the denominator by the addition of a number representing an "entrance time". The Brooklyn practice has been to determine the intensity directly from the formula $i = \frac{150}{t+20}$ where "t" represented the time required for the storm water to reach the point under study, this time to include entrance time and time through the sewers. The author knows that Kenneth Allen, M.M.E.N.Y., and his associates in the Board of Estimate and Apportionment, and a committee of The Municipal Engineers have investigated this subject. They have offered, as a curve that may be of general application to the City of New York, one that gives less intensities for a given time than the one mentioned here. We feel that we want to know much more about it before we reach any definite conclusion.

VICTOR H. REICHELT,* M.M.E.N.Y.—The paper read by the author was full of interest and described admirably in a practical way the subject of design and construction of sewers. There are a few points about which the speaker would ask the author for additional information. The author mentioned, that in the design of grades for sewers in Brooklyn, gradients were fixed which will keep the velocities of flow within the limits of 2½ feet and 12 feet per second. On account of the steep slopes existing in many places in the Borough of Richmond, we have given the matter of maximum velocities special attention.

The investigation of a combined sewer built in 1901 and laid to a grade producing a velocity of 21 feet per second when flowing full, disclosed no indication of any erosion whatsoever. This sewer is an egg-shaped one of a size 4 feet 8 inches by 7 feet. The invert up to the springing-line is lined with vitrified brick. The outlying sections of the drainage area are undeveloped and during heavy rains the sewer carries a considerable amount of silt and débris, which makes the erosion test extremely severe. In view of this fact, and in consideration of the heavy additional cost of construction involved by limiting sewers on steep slopes to a maximum velocity as low as 12 feet per second, we felt justified to set the maximum

* Assistant Engineer, Bureau of Engineering, Office of President of Borough of Richmond.

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allowable velocity at 16 feet per second and allow even a higher limit in exceptional cases, making proper provision against erosion in the lining of the sewers. The speaker would be glad to hear from the author of any investigations which may have been made in this matter in Brooklyn.

One other point the speaker wishes to discuss is the preference of combined sewers over separate sewers as expressed by the author. Where the sewer district is a city section, or will develop into such within a reasonable number of years, the speaker agrees with the author that the combined system of sewers is the preferable one; but where the district to be sewered may not develop into a city section for many years, the speaker believes that the separate system is in many instances preferable and often the only one, which on account of cost, it is possible to build.

The author mentioned that the cost of the assessment for combined sewers in Brooklyn was about 12 cents per square foot. This is more than the valuation of the property in many of the outlying sections of the Borough of Richmond. Except in the well built-up sections, the legal limitations on the amount of assessment will not permit the construction of combined sewers on account of their cost and the only way open is the construction of separate sanitary sewers that meet the immediate requirements of the district. The storm water must be drained off through the gutters to the natural water-courses. With the development of the district these water-courses will gradually be superseded by storm-water sewers, which would, however, only become necessary in certain streets, following the natural drainage lines of the district. This system of drainage has the advantage of adaptation to the growing needs of the district, without making the initial cost excessive.

MR. RIEDEL.—With regard to the velocities. We have felt for the last 15 years that the character of the material that was available outside of vitrified brick, did not warrant building for velocities greater than 12 feet per second. The author quite agrees that if we lined our sewers with a material not subject to abrasion that we might increase the velocities to 20 or 25 feet; but we in Brooklyn could not be extravagant with our grades. We have no surface elevations of over 150 feet, and it is only in a few cases where we could use such grades as the preceding speaker mentions. However, our maximum limit has been 12 feet, and in the case of the St. Nicholas Avenue interborough sewers, where we built a 180-inch

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structure with a capacity of over 2,500 cubic feet per second, we felt that we did not care to have the large volume of water carried by it approach the outlet canal at any velocity greater than 12 feet per second. Therefore we designed the sewer to have a 12-foot velocity.

With regard to the installation of separate systems in rural communities, it may be, as the preceding speaker states, economical for the Borough of Richmond to make such arrangements, because, as the author understands it, one would not have to build below the water-table. The construction of sanitary sewers in Brooklyn has been compelled because of the low-lying area adjacent to Jamaica bay, and wherever we built these sewers we encountered water, and wherever we encountered water we ran up the cost to such an amount as to make everybody connected with it alarmed. In a rural community that may not develop for 30 years, the temporary system may be wiser, and if the value of the property would not warrant the expenditure, the author would advocate by all means the construction of such a system as would give such locality sewerage systems that it needed and could pay for.

Mr. Reichelt.—In the matter of the lining of the sewers. All the sewers have been lined with either blocks or brick. Does the author consider it necessary to have this lining; that is, to go to the additonal expense instead of using simply the concrete invert? No doubt the concrete construction would be the cheapest of all. Has it come to the author's knowledge in any way that concrete would not stand the wear of ordinary gradients?

Mr. Riedel.—The preceding speaker has touched upon another point that might become the subject of acrimonious discussion. We, in Brooklyn, feel from our limited experience, but somewhat wide observation, that sewers built with concrete inverts are not as lasting nor as appropriate for the purpose to which we will subject them in Brooklyn, as a structure lined with a material over which we have far more control than we have over the forming of concrete on flat bottoms or for sloped bottoms. The author doubts the practicability or possibility of constructing a concrete invert of a smooth character; he believes that in nearly every case it will be necessary for the contractor to return and plaster it or smooth it.

One cannot get a sidewalk finish upon the concrete on a sewer bottom, because no operations can be undertaken until the forms

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have been removed and it would be unwise, if not unsafe, to remove them until the concrete has set. If one could construct a concrete bottom so that there would be an unbroken skin over it, perhaps it would serve the purpose, but we feel that we are not extravagant in Brooklyn, but rather are safeguarding the interest of the tax-payer in giving him a structure that is lined with a material that will far outlast a concrete invert lining. That is, however, the author's personal opinion, which is concurred in by his associates in Brooklyn.

PHILIP P. FARLEY,* M.M.E.N.Y.—The Chairman wishes to extend to the author the thanks of the Society for his very excellent paper, and would like to say also, that in order to complete the value of the paper, that members of the Society who are interested in this question should write their discussions out and send them to the Secretary, in order that we will have a complete story in connection with the sewer designs which will be of service to the Society and of service to the City of New York.

* President of the Society; Consulting Engineer, Office of President of Borough of Brooklyn.

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Buffalo, N. Y.—George H. Norton, City Engineer, writes of a 14,500-acre watershed, of which 10,500 acres are in farmlands outside the city, for which 60 per cent. was used inside the city limits and 25 per cent. outside. In a certain residential area 40 per cent. is being used.

Louisville, Ky.—J. B. F. Breed, Chief Engineer, Commissioner of Sewerage, says that up to last August the McMath formula had been used, with co-efficients of from 0.60 to 0.75. Metcalf and Eddy have adopted the following co-efficients in planning for future work at Louisville:

Duration of Precipitation—Minutes	Run-Off Co-efficient for Zone After Duration Stated	
	Impervious Surfaces	Previous Surfaces
5	0.50	0.10
10	0.60	0.20
20	0.80	0.35
30	0.85	0.40
45	0.90	0.45
60	0.95	0.50
180	0.95	0.70

San Francisco, Cal.—For downtown districts uses 85 per cent. (*Engineering World*, February 1, 1919).

Cincinnati, Ohio—H. S. Morse, Engineer in Charge, and H. P. Eddy, Consulting Engineer, generally used 70 per cent. for completely-developed districts, but in special cases as high as 85 per cent.

Boston, Mass.—Careful studies of the Back Bay (chiefly residential) district were made by Kuichling and Bryant and by the Sewer Division. For four sub-districts the former recommended co-efficients of from 61.8 to 72.3 per cent.* and the latter of from 69.3 to 88.8 per cent. At present F. A. Lovejoy, Engineer of Design, states that a resultant co-efficient is reached from assigning the following factors to component areas:

For roofs, granolithic, asphalt, etc.....95 to 100 per cent.
For good macadam, brick sidewalks, etc..70 to 90 per cent.
For dirt or clay yards, roadways, etc....20 to 70 per cent.

*372 acres taken as impervious of a total of 566 acres.

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Rochester, N. Y. ...	58.2 per cent.	E. Kuichling
Omaha, Neb.....	60.6 per cent.	Alvah Grover
Chicago, Ill.....	78 per cent.	L. K. Sherman
London, Eng.....	94 per cent.	quoted by Baumeister
Birmingham, Eng....	96-126 per cent.	quoted by Metcalf and Eddy
Cambridge, Mass....	100 per cent.	quoted by Metcalf and Eddy
Washington, D. C...	100 per cent.	quoted by Metcalf and Eddy
Wilmington, Del....	79 per cent.	quoted by Metcalf and Eddy
Pawtucket, R. I.....	87 per cent.	quoted by Metcalf and Eddy
Philadelphia, Pa....	98 per cent.	quoted by Metcalf and Eddy
Rochester, N. Y.....	65 per cent.	quoted by Metcalf and Eddy
Hartford, Conn.....	100 per cent.	quoted by Metcalf and Eddy

It is probable that if an average of the run-off factors used by a number of well-qualified engineers were struck it would be a fairly safe figure to adopt; but in a matter of so much moment the author does well to emphasize the desirability of securing full and convincing data applicable to New York City conditions as a matter of prudence and true economy.

Tide-Gates.—The favorable opinion expressed by the author as to the serviceability of tide-gates is believed to be warranted in spite of a certain amount of skepticism prevailing among those unfamiliar with their use, for there are many successful examples in Great Britain, and in this country they may be found at Washington, D. C., Atlantic City, N. J., Philadelphia, Pa., Boston, Mass., and elsewhere. At the last-named city there were some four hundred in satisfactory operation several years ago. They rarely need attention but are inspected about once a fortnight. In The Bronx we have an example at the crossing of Fort Schuyler road with Westchester creek, where two gates 5 feet 8 inches wide by 7 feet 8 inches high have been in operation for about 3½ years, and in the White Plains avenue sewer, where a gate 15 feet wide by 8 feet 6 inches high has been in operation about two years.

Hand or float-operated sluice-gates have been used for this purpose at Portsmouth, England, but in general tide-gates are either of the "flap-valve" or of the "barn-door" or "penstock" type, similar to the gates of a canal lock.

The "barn-door" gate has been used in Boston in the past and has been employed more or less in England at large sewer outlets, but a flap hung from horizontal pivots at the top is the type now in almost universal use. It is simple and effective and where the vertical dimension is too great may be constructed in two or more sections, one above the other.

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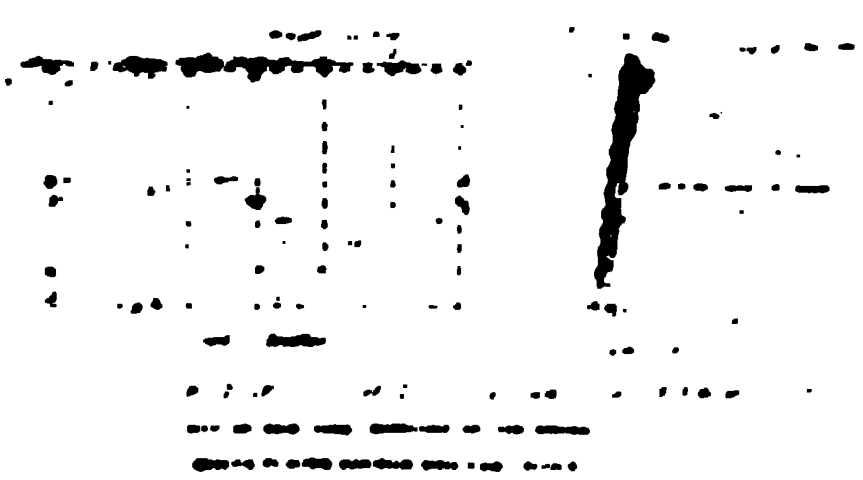

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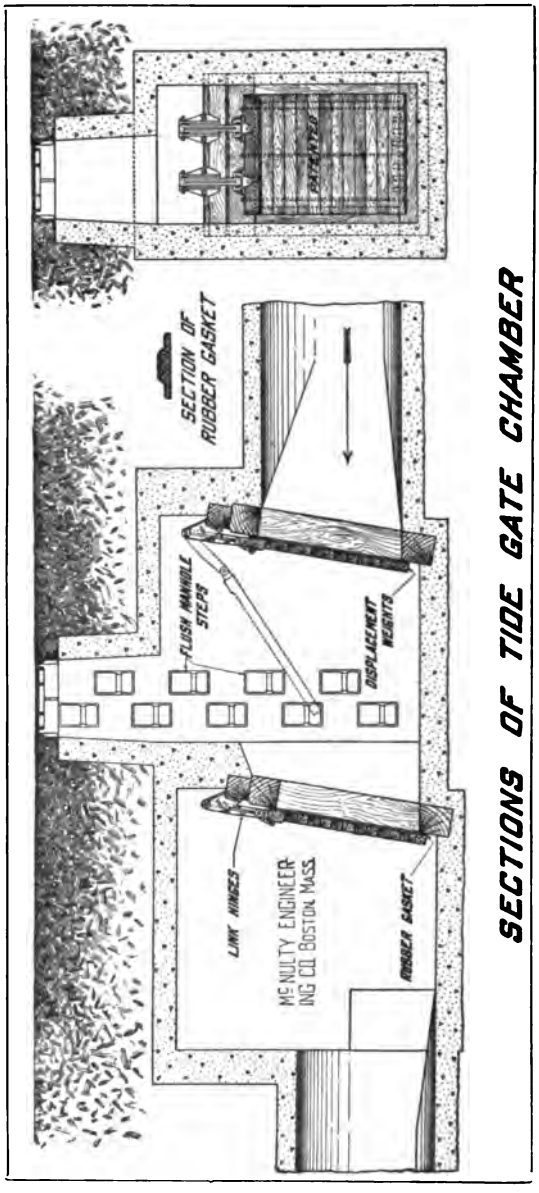

SECTIONS OF TIDE GATE CHAMBER

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At Boston, leakage is detected by inserting a salinometer in the sewage above the gate, by which the increased specific gravity due to the salt water is indicated.

The Bronx gate has no gaskets, a seat considered of sufficient tightness being obtained by the contact between the wooden gate and a heavy wooden strip embedded in the concrete (see illustration). Kuichling gives the loss of head in passing a pair of large tide-gates at Boston as three inches for each, and Mr. Phillips writes that at Washington the loss is from three to six inches per gate.

Tide-gates are useful in preventing the admission of harbor water to sewers, resulting in the deposition of sludge, or to interceptors. Clogging is possible but is not frequent in well-designed gates, and the danger is reduced by installing duplicate gates, in tandem.

WALTER W. COHEN,* M.M.E.N.Y.—The author's paper on the Ralph Avenue Sewer System in Brooklyn was about as complete and comprehensive a discourse on the subject as we sewerage designers ever had the good fortune to hear in a short article.

In Manhattan borough, especially south of 59th street, we have about the most complicated and involved sewerage-design conditions to be found anywhere. There are districts below 14th street as large as 35 acres with catchment surfaces practically entirely impervious, and were it not for the usual storm-water sumpings, the run-offs would equal the rainfalls. Likewise for high dry-weather flow. We have the case of the Woolworth Building as an extreme example, discharging upwards of a cubic foot per second from its one acre of ground area during the business day. The designs also have to consider very congested street subsurface conditions, in many streets the pipes and appurtenances and other substructures practically occupying all the suitable sewer space except the restricted space for the existing sewers. On rapid-transit subway streets the service pipes are usually crowded into a small area over the subway roofs. The street traffic congestion also makes it desirable to so design sewers for reconstruction, that interference with such traffic in extent and duration may be at a minimum.†

* Assistant Engineer, Sewer Bureau, Office of President of Borough of Manhattan.

†The standard minimum size for such conditions is a 3-foot 6-inch by 2-foot 4-inch egg-shaped sewer, this being the smallest size that will enable connections, repairs, etc., to be made from the inside. It is felt by many that this minimum should be built generally where intensive development has taken place or is to be expected.—*Editor.*

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The amount and value of perishable merchandise stored in cellars and basements throughout the business districts would more than rival the treasure stores of any other city area in history, making sewage overflow or rainwater back-up over these goods very destructive and costly.

One of our simplifying factors, of course, is the large number of sewer outlets, there being about two hundred in all, but notwithstanding these, it may be surprising to know that we have some trunk-sewer outlets in which is takes about an hour for the maximum storm-water flow to collect.

Most of the collection systems in the older sections of the borough are over fifty years old, a large part having been built just before and after the Civil War. A great number of these sewers are inadequate in size and structure, and many have settled, this being probably due to subsequent adjacent construction. An example of the condition of some of the older sewers was recently brought to our attention when an old street pavement was removed for replacement near 14th street and Sixth avenue, and it was found that daylight filtered down into the underlying brick sewer through fissures in the earth and brickwork.

Some work has been done toward a comprehensive re-design of the entire borough sewerage system, but has been mostly confined to fundamental and general principles. This work has largely been limited to districts where reconstruction was urgently necessary or it was influenced by other improvements.

The importance of gagings for both storm-water run-off and dry-weather flow data was long ago recognized and over ten years ago the department engineers then responsible for that work established sewer-gages in special gaging-chamber stations in several of the typical borough sewers and rain-gages in a few locations. One such sewer-gaging station and three companion rain-gages were established in the West 96th street sewer district, and a talk on these gagings was a part of a paper read before the Society some time ago.* The sewer-gage was a "Sanborn Pneumatic Water Stage Register" and this was carefully rated for relative quantity of flow in the sewer with a standard weir built therein, and with pitot tubes, the results being compared with approximate adjacent sewer flows, with the usual assumptions and also the usual indifferent success.

These pneumatic registers have recently been so perfected that they now are rugged enough to accurately indicate stages of gasoline in

* Paper 115, by WALTER S. MCGRANE, published in the February, 1918, issue of MUNICIPAL ENGINEERS JOURNAL.

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traveling auto-tanks, and probably their pressure variations could be piped far enough now to permit sewer and rain charts being operated by single clocks, thus obviating one of the past troubles in sewer run-off gagings.

Records were obtained for some time from the 96th street gages and our late Past President, Charles E. Gregory, a keen and enthusiastic student of the subject, was engaged at the time of his death in analyzing these results with the view of at least trying to establish therefrom an approximate general run-off formula or practical factors which might be used generally in the design of sewers for ultra-urban districts. It would seem quite a reasonable assumption that if a large enough typical district could be properly gaged that an analysis of such gagings would produce valuable data for design.

Of course, as the author very properly says in his remarks, this matter of run-off must be handled with caution and mature judgment but, at the same time, no less an authority than the late Emil Kuichling believed that while the much-mooted run-off factor was a true variable for two districts or for two storms, at the same time this variable surely had its restricting definite limits; for instance and comparison: while Easter Sunday varies annually in its calendar date, we know it falls around April 1, and could not vary all over the year. Considering that the investment in sewerage is so considerable, the desirability of reliable design data is much to be wished for.

Practically all our design for the south half of the borough is replacement of the old worn-out inadequate system. Especially deep two-level and, in one case three-level, rapid-transit routes have of recent years caused the construction of several low-level tunnel relief sewers, one of which discharging at the foot of East 26th street is now being built. Special features of these designs were snow-dumping and dry-well manholes and ogee water-drops with treatment-plant incidentals. The lower Sixth Avenue and Clarkson Street outlet sewer to the Hudson river was designed recently for reconstruction as a semi-separate system with generally improved drainage benefit conditions. This plan contains a pre-cast concrete-pipe sanitary interceptor laid in West street from a storm outlet at Clarkson street down to a treatment plant near Canal street and the Hudson river.

Another recent design was a separate sanitary system covering the low-lying district around Grand street and West Broadway, with a temporary sewage-pumping station at Thompson and Canal streets, the station being placed under the sidewalk in Canal street and

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pumping the sewage out of the new normal-depth sanitary system up into the old Canal street combined sewer. This improvement permits satisfactory house connections in this district for the first time, and these were the first separate sanitary sewers built in the lower part of the borough. Some separate-system sewers were built in the extreme northern part of Manhattan within the last fifteen years.

Our first treatment plant was designed and built recently at the foot of Dyckman street on the Hudson river, and consists of two 14-foot-diameter Riensch-Wurl fine screens and appurtenances with a submerged outfall to beyond the pier-head line in 50 feet of water. This plant conforms to the tentative comprehensive policy of the City authorities permitting the limited treatment method of fine screening for the Hudson river outlets. This policy gives Manhattan borough considerable leeway in its disposal plans, as about one-half our sewage discharges into the Hudson river directly. Contracts have been let for a somewhat similar but larger treatment plant at Canal street and the Hudson river, using the Rex Band type of screen made by the Chain Belt Co.

The prospective future development of our borough is about as involved as in the City at large. It seems quite possible that the residential character south of 59th street will eventually almost entirely give way to business and commerce, and one can easily picture a very modern marginal way around the island, largely lined with wharves and warehouses, storehouses, markets and such like; and by the same token, the undeveloped upper part of the borough will almost surely build up with closely-placed good-class apartments. There is already serious talk by eminent engineers and capitalists about extending the island southerly beyond Governor's island, thereby creating additionally as much and as valuable land as now lies south of 14th street. One of the sketches plans three-level streets, and if this will allow three levels for sewers and drains, the writer guesses the sewerage problems will not be very much to bother designers.

The matter of sewage treatment in Manhattan, outside of the Hudson river plants mentioned, stands about in the same old *status quo*. We are still patiently waiting for that ideal method and plant requested by George T. Hammond, M.M.E.N.Y., of Brooklyn, some years ago—the one which will take up about as much space as a telephone booth, be odorless, almost costless, and will spout the effluent out of one end through an attractive nector fountain, the

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Character of Drainage District	Population Per Acre	Water Consumption, Cubic Feet Per Second Per Acre
Large hotels, high-class residences...	66-96	0.023
East Side tenements	550	0.032 to 0.050
High-class apartments	176	0.020 to 0.028
Office buildings—water-front—total.	496	0.064
Medium-class apartments	224	0.034

A check computation on the above constants may be obtained in the following manner: Estimate the total floor area of the buildings of the district, either for present or future development; the water consumption is approximately a constant of 350 gallons per day per 1,000 square feet of floor area.

Seepage, or infiltration, depends on ground conditions and tightness of the sewer construction and is a very variable quantity. The leakage into the sewer decreases as a rule with the age of the sewer, as the cracks and joints become gradually tightened with finer particles; 50,000 to 100,000 gallons per day per mile of sewer is probably a good range for infiltration for the average vitrified-pipe or masonry sewer. In very wet ground with mediocre sewer construction, the infiltration may approach one million gallons per day per mile. In practice, the infiltration itself is not computed. A liberal value is taken for the sewage constant which is presumed to include infiltration.

The maximum rate of sewage, or dry-weather flow, including infiltration, is taken as one and one-half times the average and the minimum two-thirds the average; as an illustration, in a drainage area in a district of office buildings, the average sewage flow in the absence of other data would be approximately 0.07 cubic feet per second per acre; the maximum 0.105 cubic foot and the minimum 0.047 cubic foot per second per acre.

Storm Discharge.—To standardize run-off computations for the new sewers which have to be provided in the subway contracts, the practices of the sewer bureaus of the various boroughs have been ascertained and it has been endeavored to adopt their methods, provided they do not involve considerably increased expense on account of being recently adopted for improving the sewerage system. The problem of readjusting sewers is to replace the old and undisturbed

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sewerage system with a modified system which would be equally efficient. This of course is followed in a reasonable manner with proper regard for the interests of the City and railroad.

The methods in use in the various boroughs are different for each one. These, however, can be reduced to two: (1) The empirical method, and (2) the so-called "rational" method.

The empirical method consists of the use of a formula arrived at from observation on actual storm discharges in sewers, without representing any necessary natural relation among the various factors in the formula. Although such a formula has no rational validity and in many respects is objectionable, it is considered by some as yielding results as satisfactory as can be obtained at the present stage of our knowledge of the subject.

The Borough of Brooklyn uses the empirical method with McMath's formula $Q = CRA^{\frac{4}{5}} S^{\frac{1}{5}}$, in which R represents the rainfall rate factor and is taken as three inches per hour; A is the drainage area in acres; S is the average slope in feet per thousand feet of the ground or sewers in the drainage area; C is the run-off factor, which for a built-up territory is taken at 0.75.

The rational method is used in the Boroughs of Manhattan and The Bronx. The run-off is taken as equal to the product of the run-off factor, the rainfall intensity for the drainage area, and the drainage area. It is represented by $Q = CRA$, in which C is the run-off constant, which is generally less than unity, depending on many conditions and principally on the degree of imperviousness of the area; R is the rainfall rate in inches per hour, taken from an empirical formula showing the relation between it and the time of concentration, t, in minutes for the drainage area; A is the drainage area in acres.

In The Bronx, the following formula is used: $R = \frac{120}{t + 20}$, with $C = 0.75$ for built-up areas.

The rainfall formula approximates the "two-year rainfall curve". It gives the average rainfall intensity for any duration of rainfall in minutes, and for an extensive period this intensity will not be exceeded on the average more than once in two years.

For Manhattan borough, the New York or Hering formula appears to have been used, although not definitely adopted. This is an empirical formula similar to McMath's, having slightly different exponents. It is $Q = CRA^{0.833} S^{0.27}$, with CR equal to 1.62. As the

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results of this formula roughly approximate those of McMath's formula, the latter is used with $C = 0.90$ instead of 0.75 for Brooklyn. In addition, the rational method described for The Bronx is used and the larger run-off by these two methods is used.

The rational or time-element method is as follows: The time of concentration characteristic of the drainage shed is computed from a sewer map. A time of entry from the most remote point to the sewer is actually approximated, or taken as five minutes. The time of flow along each sewer leading to the point at which Q is to be obtained is computed. The results of their time are added to give the time of run-off of flow from the most remote point, or the time of concentration. If this time is 20 minutes, then $R = \frac{120}{t + 20} = \frac{120}{20 + 20}$ = 3 inches per hour. With a drainage area of 80 acres, and C = 0.75, the run-off is $Q = 0.75 \times 3 \times 80 = 180$ cubic feet per second.

In most cases, no additional allowance is made for the dry-weather flow in obtaining the combined discharge. Where, however, the dry-weather flow may be considerable, as in the downtown districts, it should also be computed and added to the storm flow to obtain the run-off for which the sewer is to be designed.

In using McMath's formula, the following values for C, known as the ratio of imperviousness, are to be used: 90 per cent. for the business districts of Manhattan, 80 per cent. for the residential districts of Manhattan, 85 per cent. for the business districts of Brooklyn, 75 per cent. for the more densely populated residential parts of The Bronx, Brooklyn, Queens and Richmond boroughs, and 70 to 50 per cent. for the sparsely-settled or suburban districts in The Bronx, Brooklyn, Queens and Richmond boroughs. Due consideration must be given to possible future development and growth.

Recently the Manhattan Bureau of Sewers made studies for improving its sewerage system. In this connection, it adopted the rational or time-element method excepting that the "ten-year rainfall formula" $R = \frac{150}{t + 16}$ is used with $C = 0.60$. A minimum value of ten minutes is taken for t, and no allowance is made for the dry-weather flow. The constant in the denominator is frequently given as 20 which includes an allowance for the time of entry.

Time Distribution of Excessive Rainfalls.—As a matter of interest and value, the distribution of rainfall intensities throughout a period of years is given. Although the so-called "two-year formula" gives

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the rainfall intensities which are not exceeded, on the average, more than once in two years, there have been periods of three, four and even nine years during which such intensities have not been reached. For $t = 20$ minutes, $R = \frac{120}{t + 20} = 3$ inches per hour. This rate for 20 minutes was equalled or exceeded in the following rainfalls:

Date	Maximum Rate for 20 Minutes	Interval Between Rainfalls
October 11, 1871.....	3.18	.....
July 26, 1875.....	3.81	3.79 years
August 5, 1878.....	6.93	3.02 years
May 22, 1881.....	3.57	2.80 years
August 22, 1884.....	3.18	3.25 years
August 20, 1893.....	4.35	9.00 years
May 24, 1897.....	3.03	3.76 years
July 28, 1902.....	4.20	5.18 years
August 5, 1902.....	4.05	0.02 years
August 19, 1904.....	3.21	2.04 years
July 31, 1910.....	3.21	5.95 years
May 30, 1912.....	3.21	1.83 years
July 28, 1913.....	3.93	1.16 years
September 4, 1913.....	6.00	0.19 years
October 1, 1913.....	3.45	0.08 years

In 1902, there were two rainfalls of this severity within seven days, and in 1913 three such storms within two months and three days. Then again, there were eight storms having intervals between them of over three years. The average interval for 45 years for a 3-inch rate for 20 minutes is three years instead of two years.

The distribution for the "ten-year rainfall" is still more erratic. For a 20 minute interval $R = \frac{150}{t + 16} = 4.2$ inches per hour. This was equalled or exceeded in the following rainfalls:

Date	Maximum Rate for 20 Minutes	Interval Between Rainfalls
August 5, 1878.....	6.93	.....
August 20, 1893.....	4.35	15.04 years
July 28, 1902.....	4.20	8.77 years
September 4, 1913.....	6.00	11.10 years

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VICTOR H. REICHELT,* M.M.E.N.Y.—The author's paper on the design and construction of the Ralph Avenue Sewer System in Brooklyn presents a comprehensive treatment of problems encountered in the design and construction of a sewerage system for a district rapidly developing into a well built-up city section. Due to the district containing both upland areas with fairly steep slopes and meadow areas adjacent to the bay, it covers a wide scope of problems in sewer design.

The following discussion of the paper has been written at the request of the President of the Society for a written discussion of the paper "in order to have a complete story in connection with sewer design". In the following lines are therefore pointed out some of the features and problems encountered in the design and construction of sewers for the Borough of Richmond.

The most important difference between the Boroughs of Brooklyn and Richmond is the character of their development. While practically all parts of Brooklyn are developing into closely built-up city sections, the largest part of the Borough of Richmond will remain of a rural and suburban character for a long period to come, and it would not be reasonable to apply the same standards in computations for sewers in Richmond, as in the more intensively-developed boroughs of Greater New York. Besides, the low land values in Richmond make it practically impossible to build combined sewers, based upon a complete development of the district, in all sections. A careful consideration of the drainage problems for the various portions becomes, therefore, imperative.

The topography of the borough is such that the drainage areas are generally of moderate size. A ridge divides the island longitudinally into a northern and southern part. The northeasterly section of this ridge rises to hights several hundred feet above sea-level and its slopes are steep and run close to the shore. In the central and southwesterly sections the steep slopes terminate between one and two miles from the shore; along the shore are large tracts of meadowland, which in some places extend a long distance inland. The area of densest population is in the northeasterly part of the island extending from Mariners Harbor along the shore to Fort Wadsworth and about a mile inland. With the exception of Port Richmond, West New Brighton and part of New Brighton, these districts are pro-

* Assistant Engineer, Sewer Bureau, Office of President of Borough of Richmond.

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vided with combined sewers of modern construction. There are ten sewer outlets, serving combined systems of sewers, in this part of the borough; all these have been built since the year 1901. The areas of these drainage districts range from 34 to 1,220 acres and the sizes of the outlet sewers, expressed in diameters of equivalent circular sizes, range from 2 feet 10 inches to 9 feet 3 inches.

With the exception of one, all these systems have been designed in accordance with the "rational" method, the rainfall intensity curve being expressed by the formula $R = \frac{8.91}{t^{\frac{1}{2}}}$. The percentage of maximum run-off assumed for the various parts of the drainage areas ranges from 25 to 85 per cent., according to the nature of the soil and probable development of the district; the average for a whole district ranges between 54 and 65 per cent. The time of run-off over the surface to the sewer was determined by observation of the gutter flow on various kinds of pavements. An additional period of time, varying from five to eight minutes, was added as the time of concentration of the water in the gutters. The size of the sewers was computed by Kutter's formula with $n = 0.013$ for vitrified-pipe sewers and well-finished concrete and brick masonry.

For sizes below 24 inches in diameter, vitrified pipe was used, except where special conditions required iron pipe; from 24 inches up to 5 feet in diameter, egg-shaped sewers were used wherever the depth of sewer permitted such construction. These sewers are generally built of concrete with vitrified-brick lining in the invert extending to four-tenths their hight. For sizes up to and including 2 feet 4 inches by 3 feet 6 inches one-third split vitrified channel pipe was laid in the invert. In many instances, especially in the marginal streets along the shore, where the street surface is only a few feet above high water, the head-room did not permit the construction of egg-shaped sewers. In these cases, reinforced-concrete sewers of rectangular section were built; the invert of these has a vitrified channel pipe in the middle and concrete shoulders sloping to the channel. The channel is of sufficient size to carry twice the amount of maximum dry-weather flow. House connections are carried under the shoulder directly connecting to the channel. The elevation of the outlet-sewer invert at the marginal street is kept above high-water level and here the dry-weather flow is separated from the storm-water channel and carried to the pier-head through a pipe sewer of a capacity equal to

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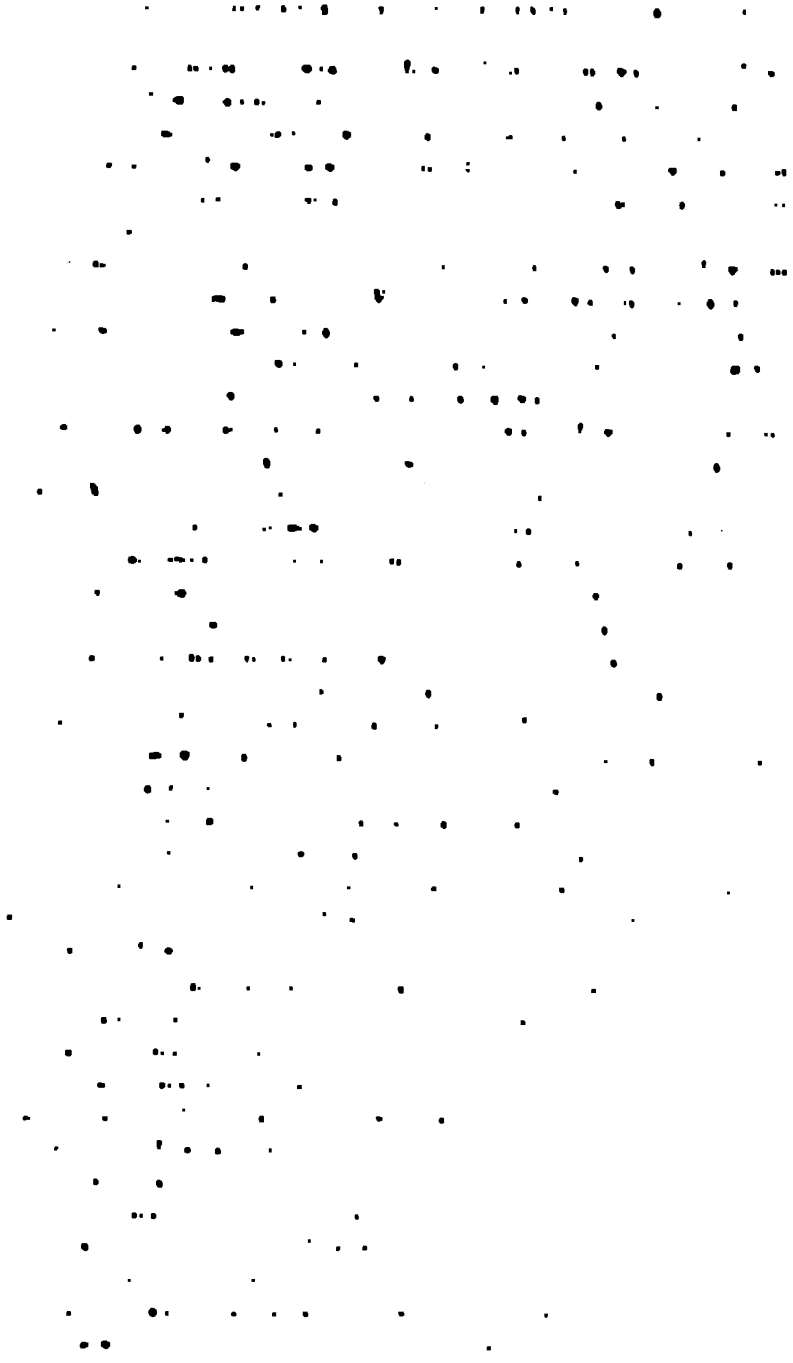

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Measurements of the flow in two of the trunk sewers were taken by means of "Friez Water Stage Registers," for the purpose of determining the run-off factor during heavy rainfalls. The rainfall was recorded by a "Draper Pluviometer," located within the drainage area. The results indicate that a maximum runoff of 40 per cent may be expected in a district about 50 per cent. developed. A detailed description of these gagings is given in a report to the committee of consulting engineers of the Board of Estimate and Apportionment and a report of the Committee on Rainfall and Runoff of the Municipal Engineers.

The part of the borough south and west of the northerly and easterly slopes presents problems of sewer design entirely different from those described above. On account of the large areas of salt-meadow land bordering the shores, and also on account of the smaller population and low land values, the combined system of sewers is not practicable. Insanitary conditions developing in some localities of this area compel the construction of sanitary sewers. This applies especially to the south shore, where the bathing beaches have in recent years attracted a large summer population and a number of bungalow colonies have developed. This has also brought about a largely increased permanent population in the adjoining upland districts.

A system of sanitary sewers for the South Beach and Midland Beach district, including the area between these beaches, and designed to provide also sanitary sewerage facilities for the upland area within the drainage district, is now under construction. The work includes the construction of a sewage-treatment and pumping plant at the outlet, which is located midway between South and Midland beaches, and two automatically-controlled relay pumping-stations, one at each of these beaches. The sewage treatment will consist of screening by fine mechanical screens and chlorinating the effluent, which is pumped through an 18-inch cast-iron force main to a point about 2,000 feet off-shore. The off-shore section of the force main is flexible-jointed pipe and was laid in a shallow trench in the bottom of the bay by means of a cradle hung from the side of a scow. A considerable part of these sewers are laid in salt meadow below low-water level.

The adjoining districts of New Dorp, Oakwood and Great Kills are now applying for sewers, and plans for a sanitary system for this area are under way.

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The storm water from these districts will, for many years to come, be taken care of by the natural water-courses. Short stretches of storm-water sewers may become necessary by reason of development of parts of the district. In general, the storm-water flow will be in the most direct line to the bay and there will be a large number of storm-water outlets serving districts of moderate size. By this method it will be possible to provide relief to the sanitary requirements of districts where the land values will not permit the construction of expensive combined systems.

A situation of somewhat different character developed in a district located to the south of Mariners Harbor, the shipbuilding section. The boom in the shipbuilding industry during the war period caused a rapid development of this section. While a complete system of combined sewers had been built in the area lying on the northern slope of the ridge which is about ¾ mile from the shore, it became necessary to provide sewers for the section on the southern slope, which has its natural drainage in a westerly direction to the Arthur Kill or Staten Island Sound.

To follow in the direction of the natural drainage line would have meant an outlet sewer two miles long through an entirely undeveloped property, a large part of which is meadow. This was found to be impracticable as the assessment for the sewer could not have been collected on account of the low land values. It was therefore decided to temporarily pump the sewage into the upper end of the nearest sewer in the adjoining district. A pumping-station, operated by electric motors, automatically controlled by floats, was built at the point of concentration of the sewers, from which a 10-inch cast-iron force main 1,700 feet long was laid to connect to the sewer in the adjoining district. This pumping-station has been in operation for 2½ years and has given satisfactory service.

The sewers, of which the largest is an 18-inch pipe, are all laid with joints poured with "G-K" compound, to reduce the infiltration of ground-water to a minimum. The manholes are built entirely of concrete. The capacity of the pumping-plant is only about one-third of that which will be required when the district is fully developed; the sewers, however, are designed for a full development. When the amount of sewage flow reaches the limit of the plant, the final outlet sewer will be built and the pumping-plant abandoned. It is expected that by that time the district through which the outlet sewer passes will be sufficiently developed to require and be able to pay for this sewer.

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meet modern requirements. New York City owes its ranking position to the fact that most of these wonderful advantages fall within its confines, and what has been commonly referred to as the "Port Problem" is the method to be used in adapting the inheritance of early-day development to present-day needs. In its first stages the comparatively modest demands of commerce were fully met through the construction of piers and storage sheds immediately adjoining, the local needs being served by trucking and the interchange for foreign and coastwise movement effected by crude methods of transfer. With the advent of the railroad, the Hudson river, which had previously been the important freight carrier from the north and west, became at once a barrier to separate rail traffic to the New York water-front from the west, and then followed the great development of float and lighterage service which is depended upon to-day as the means of bridging the waterway intervening between the terminals at this great center of the commerce of the nation. On the easterly side of this barrier there are the New York Central railroad with its freight line on the easterly side of the Hudson river, and the New York, New Haven and Hartford railroad with its terminal yards on the East and Harlem rivers in the lower part of the Borough of The Bronx, and its extension along the New York Connecting and the Long Island railroads, the latter serving the Long Island district, to a water-front yard in Bay Ridge, in the Borough of Brooklyn. On the westerly side of the port the railroads may be separated into a northerly and a southerly group, the former comprising the West Shore, the New York, Ontario and Western, the Erie and the Delaware, Lackawanna and Western, and the latter the Pennsylvania, the Philadelphia and Reading, the Baltimore and Ohio, the Jersey Central and the Lehigh Valley. Of the twelve trunk lines, it will be seen that nine are located on the New Jersey side of the port, and that of the remaining three the New York Central is the only one which penetrates the heart of the commercial district.

Possibly it is by reason of the competition incident to the superior advantage possessed by the New York Central in its relation to the docks along the New York City water-front as compared with the position of the other trunk-line railroads, and possibly by reason of mutual jealousy between the railroads, that there has been established the practice of delivering freight to and from any point on the water-front between Fort Lee on the north,

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The case was defended by the State and City of New York and by representatives of the important interests which were seriously affected, the replies setting up the contention that the granting of the application would divide the Port of New York into two ports and develop a rivalry disadvantageous to both, that such a course would result in serious damage to the port, with accrual of certain advantages to the New Jersey interests, and that the Metropolitan district was a natural rate zone. The case is such an important one that a quotation from the review of it. as presented by Commissioner Harlan, is pertinent at this time when all of the issues are so prominently before the public:

> "The complainants take the position that the inadequacy of the present facilities at the Port of New York and the consequent congestion of freight there, are attributable at least in part to the application of a common rate of freight to and from points bordering on the harbor. As long as the railroads perform the expensive lighterage and floatage service without imposing an additional charge therefor, the freight rates offer no inducement to the steamship companies to seek pier space on the New Jersey shore rather than in Manhattan or Brooklyn; and the maintenance of a common rate to and from both sides of the port tends to increase rather than to diminish the congestion of freight on the shores of Manhattan and Brooklyn. If the freight rates to and from the New Jersey shore were lower, ocean shipping would be attracted to the New Jersey side of the harbor and more industries would be induced to locate there. The complainants contend that this result would be desirable, not only because it would relieve the congestion at the port, an ever-present problem, but because it would enable the defendants to avoid the great expense they now incur in performing a transfer service which the complainants deem unnecessary. There is some disagreement among the witnesses as to whether or not the present practice of handling freight in lighters is wasteful, nor are they in accord as to the relative advantages and disadvantages of loading and unloading freight directly between piers and vessels on the one hand and lightering it on the other. It seems to be agreed that solid train-loads of some commodities may be loaded and unloaded most economically and expeditiously if facilities are provided for the direct interchange of freight between car and vessel, and that lighters may be employed to better advantage when the cargo is of a miscellaneous character. The vessels entering and leaving New York harbor usually carry miscellan-

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rates of freight applying over all the routes, practically the only field of competition left to the railroads is that provided by their separate terminal operations. A shipper will employ the services of the carrier which offers him the most convenient facilities for the receipt and delivery of his shipments. It is this rivalry between the railroads in the matter of terminal service that has induced them to lay hold of almost every available foot of land on the New Jersey side of the harbor. It is this rivalry that prevents the establishment of reciprocal switching arrangements and joint terminal operation on the New Jersey shore, and for the difficulties encountered in endeavoring to persuade the railroads to construct freight tunnels under the river between New Jersey and Manhattan. And it is this rivalry that tempts the carriers to invest large sums in new terminals for their individual use instead of uniting in a common effort to solve in a larger way a problem whose solution can never be attained as long as the present policy of unrestrained competition is continued. It is not too much to expect that the defendants will take immediate steps to reorganize and co-ordinate their terminal facilities at the port. There can be no justification, especially in a time of national emergency, for a policy that permits certain terminals to be congested with a surplus of freight while at the same time a nearby terminal has not enough traffic to keep it busy. *It is necessary that the great terminals at the Port of New York be made practically one, and that the separate interests of the individual carriers, so long an insuperable obstacle to any constructive plan of terminal development, be subordinated to the public interest.*"

This decision was followed in 1917 by a movement to bring about unity between both states in dealing with the port problem through the creation, under special legislative acts by both states, of the New York-New Jersey Port and Harbor Development Commission made up of three representatives from each state appointed by the respective governors. This Commission began active work in 1918 and presented its final and joint report to the governors of both states under date of December 16, 1920, with a number of recommendations, of which the more important and specifically recommended for adoption comprise:

(1) Creation by both states of a single port authority;

(2) Construction of an automatic electric railroad system to operate between the New Jersey railroads and joint terminal stations in the Borough of Manhattan for the handling of general merchandise and food products;

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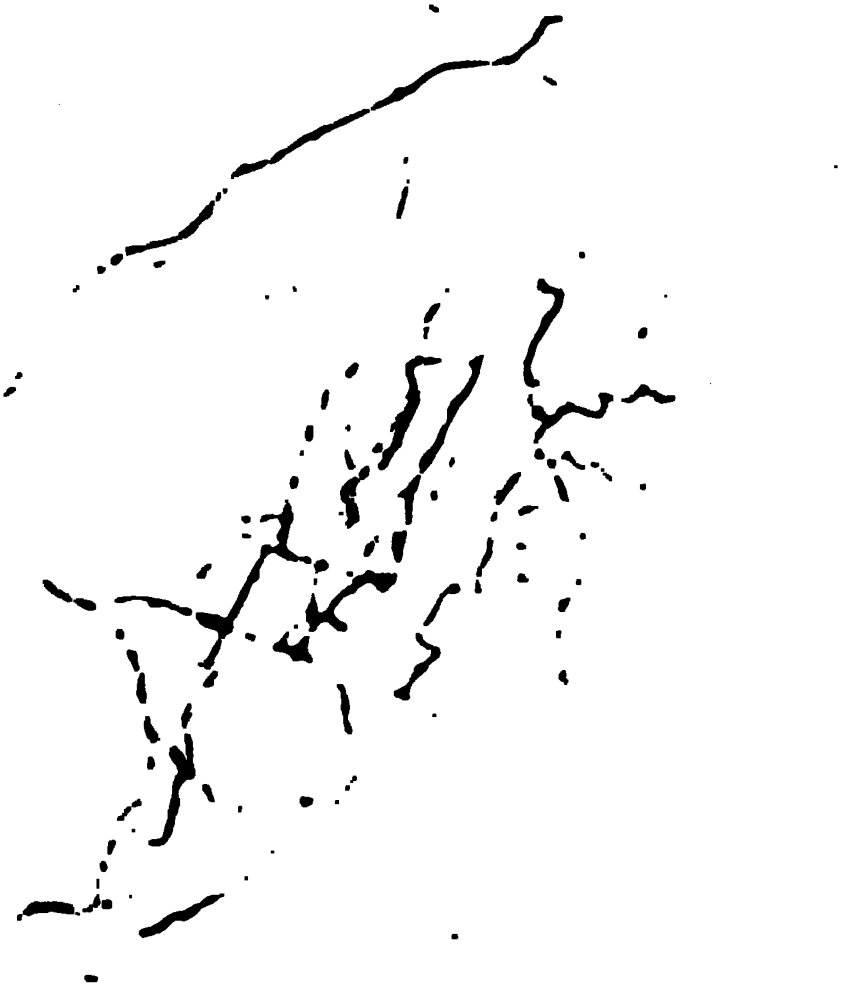

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(3) The development of inner and middle belt-line railroads as a part of a general belt-line system in New York and New Jersey, and of an outer belt-line railroad in New Jersey;

(4) Consolidation of the remaining railroad marine operations by use of joint rail-head terminals.

The automatic electric system recommended as the first comprehensive undertaking to be carried out was to have a capacity to meet a movement estimated for 1929 at a volume of 10,000,000 tons per annum, but so designed that through the addition of other terminal stations this could be brought up to a capacity of 14,000,000 tons per year. It was also estimated that it would cost $201,000,000 to install this system and that through its operation the cost of moving freight from the break-up yards in New Jersey to the Manhattan stations would be reduced from $2.25 to $1.82 per ton, representing a saving of $0.43 per ton or 2.15 per cent. profit on the investment with an assumed interest rate of 5 per cent. There was also expressed the conclusion that through the introduction of this system, what is known as the West Side freight distribution problem will have been solved, and that upon the correct solution of this problem depended the solution of the port problem as a whole.

In this report there is presented the result of three years' study of the problem, to meet the expense of which appropriations to the amount of $225,000 have been made by the legislatures of each state, or a total of $450,000. In it there are disclosed data relative to the movement of freight and the cost thereof in detail never before assembled and, in short, an analysis of conditions as they existed in 1914, or the last normal year before the war, which may be said to be of an encyclopedic character.

No specific plans or cost estimates are given for the other improvements recommended, and from the report of the Commission it would appear that the construction of what is designated as the outer belt-line railroad was to be left to the distant future and that other than as to the Borough of Manhattan, it was proposed to indefinitely continue the use of float service for the interchange of traffic between the railroads and commercial interests now separated by the waters of New York harbor.

The New York-New Jersey Port and Harbor Development Commission was superseded on April 25, 1921, by "The Port of New York Authority", created under the provisions of a joint act of the

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given no voice in the formulation or management of the proposed undertaking, the naturalness and occasion for which it is not difficult to see. The intrusion of the State into the management of the City has been the occasion for growing resentment which has recently been emphatically expressed. It is furthermore evident that there can be no guarantee that the jealousy of local community interests, which it is sought to avoid, will not crop out with equal force in the Bi-State Commission, and as the terms of the proposed union of port interests are so binding that it would be very difficult to withdraw from them even if the consolidation of interests should later prove ineffective or unsatisfactory, the resulting confusion in case of a deadlock might prove disastrous. Again, the pooling, on equal terms, of the economic interests of a single community of nearly 6,000,000 inhabitants with those of 104 scattered municipalities having a total population of about 2,500,000 and very much smaller assets, does not represent what would seem to be a sound policy, and particularly when the issues involved are of only a general character and do not bear with equal force upon the respective parties, the one having the lesser interest taking a far less risk than the other as to the outcome of the combination.

If the principle be accepted as a correct one, it would seem to follow that similar Bi-State commissions should take general charge of the water-supply, drainage and sewerage, and rapid-transit problems of the Metropolitan district regardless of state lines. While such an arrangement might be considered as advantageous in many respects, the conflict of laws and interests by reason of dual jurisdiction which could not be fully avoided, with the possibility of resulting endless confusion and clash would seem to warrant very serious hesitation over any such commitment, but would rather point either to a joining of state interests only in the carrying out of particular and clearly defined projects or the setting up of an independent state as a better means of securing the desired end. If the former alternative is selected, it would also seem that the interests of the City of New York, financial and otherwise, should always be recognized by at least giving it strong direct representation on any such Bi-State commission in which its affairs are so deeply concerned.

At almost the same moment that the Legislature created the Port Authority, it also passed an act which became effective on May 12, 1921, directing the Board of Estimate and Apportionment, without seeking on its part, to proceed within two years to con-

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struct a freight and passenger tunnel between the Boroughs of Brooklyn and Richmond for the purpose of "improving and increasing the terminal facilities of the City of New York to maintain the supremacy of the Port of New York."

In a recent speech before the Brooklyn Chamber of Commerce, His Excellency, Governor Miller, referred to this measure as follows:

> "I recognized the fact that that bill was going about it in the wrong way, but I wanted to do anything I could to stimulate the investigation of this subject. I knew perfectly well that certainly before another session of the Legislature, it would be impossible to do anything under that bill except investigate. I thought that an independent investigation would do no harm and for the purpose of stimulating the study of this subject, I put my signature to a bill which was so defective upon its face as to be unworkable."

It so happened that at the time when this bill was signed, the writer, acting as a member of a special committee appointed by the Board of Estimate and Apportionment, was studying the practicability of developing railroad facilities for the twelve municipal piers nearing completion at Stapleton, Staten Island, representing an expenditure of about $25,000,000, and that the City was also shaping plans for actively advancing the development of Jamaica bay incidental to which railroad facilities are absolutely essential and a mainland connection extremely desirable. This opportunity for the simultaneous advancement of two great projects seemed little short of miraculous, and it is, therefore, not to be wondered at that no time was lost by the City in acting upon the legislative mandate.

In the belief that these particular projects were the ones most directly concerned, the Board on May 20, 1921, appointed a Committee, consisting of the Chief Engineer of the Board of Estimate and Apportionment, the Commissioner of Docks, the Commissioner of Plant and Structures and the Engineer of the Borough of Richmond, to confer with representatives of the Pennsylvania, the Baltimore and Ohio and the Long Island railroads, for the purpose of determining the practicability of putting into effect a definite plan whereby proposed railroad facilities at Stapleton and across The Narrows might be made available and as to the terms to be arranged to this end, and on June 17, 1921, it appropriated $150,000 to meet the preliminary expenses and directed the Chief Engineer of the Board of Estimate and Apportionment to take charge of the engi-

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neering features of the enterprise. During the month of August the staff was organized and at its close a strong corps, now numbering 32 men, had been built up, including in its membership men who had been connected in some responsible and well-recognized capacity with every important trunk-line railroad and tunnel project carried out in the Metropolitan district during the last twenty years, and one which will compare favorably with any engineering staff ever engaged either on tunnel or railroad projects. In this connection, it is only fitting that there should be a word of appreciation of the co-operation of the chief engineers of the Transit Commission and the New York-New Jersey Vehicular Tunnel Commission, both of whom sacrificed personal convenience in releasing men to this service.

In the meantime a further study of the problem led the Committee on Negotiations to the conclusion that instead of having a Jamaica Bay-Stapleton improvement to deal with, they had in the project assigned to them the real solution of the Port of New York problem for which such an extended quest had been made, and with that thought in view, His Honor, the Mayor, at the request of the Committee, called together the heads of the twelve trunk-line railroads entering the Metropolitan district for conference in the matter. This step disclosed a very substantial interest in the project on the part of the eleven railroads represented and resulted in the formation of a joint committee, consisting of the engineering heads of the various railroads, acting with the Chief Engineer of the Board of Estimate and Apportionment, to consider the entire question, with directions to report back to an Executive Committee consisting of the railroad heads and His Honor, the Mayor, which Committee at its meeting of August 16 fixed October 25 as the date for further consideration of the matter.

The report of the Chief Engineer of the Board of Estimate and Apportionment, together with those of his staff, was issued under date of October 15, 1921, or ten days before the time set for its consideration, and has been widely circulated. In it there was presented a plan for a belt-line railroad traversing territory in New Jersey and Staten Island entirely free from railroad congestion, leading to a tunnel across The Narrows to connect with the New York, New Haven and Hartford railroad via the Long Island and New York Connecting railroads, with provisions for an extension to connect the New York, New Haven and Hartford railroad with the New York Central railroad, and thus intercepting every one

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of the trunk-line railroads of the Metropolitan district. The plan also contemplated the introduction of a series of industrial railroads to serve great water-front areas, some of which have been so favorably located that they could develop notwithstanding the absence of railroad facilities, while others, of almost unlimited extent, are ripe for development as soon as such facilities can be provided. As planned, it was believed that the project, by removing through freight from the Manhattan and New Jersey water-front, and thus relieving these areas from the burden of serving as distributing points for Metropolitan territory from which they are far removed, would go a long way in relieving the freight-congested districts, and to such an extent as to avoid the widely-advertised complaints in this direction. The studies as to the economics of the project as presented in this report have since and are still being considered by the railroad engineers, pending the completion of which the report back to the executives is being deferred.

While the engineering features of the project have escaped adverse criticism, the report has been bitterly assailed in several quarters as representing an invasion of a field assigned to the Port Authority, the only answer to which charge is that, under the provisions of the legislative act, the Board of Estimate and Apportionment was given no option as to procedure but was enjoined to undertake the very work which has been done, and that, if a criticism of this character is justified, it follows that the Port Authority, which derived its power from the same source, has likewise invaded the field of the Board of Estimate and Apportionment. It has also been charged that the City was endeavoring to build railroads outside the limits of the City, in reply to which it may be said that the formulation of a plan for a belt line was undertaken at the request of the railroad executives and presumably with a view to its construction and operation by all of them on a joint basis. While it may be admitted that the Enabling Act is crude, it is proposed to expand the powers granted under it in such a way as to remove any doubt as to the terms being broad enough to adequately fit its title and a bill to that end will be introduced at the opening of the next legislative session.

On the other hand, the plan as now published by the Port Authority carries with it an endorsement in principle of the Narrows Tunnel plan of the highest character, as that body has apparently discarded the recommendation of its predecessors to the effect that the first step in the improvement of the port facilities should consist

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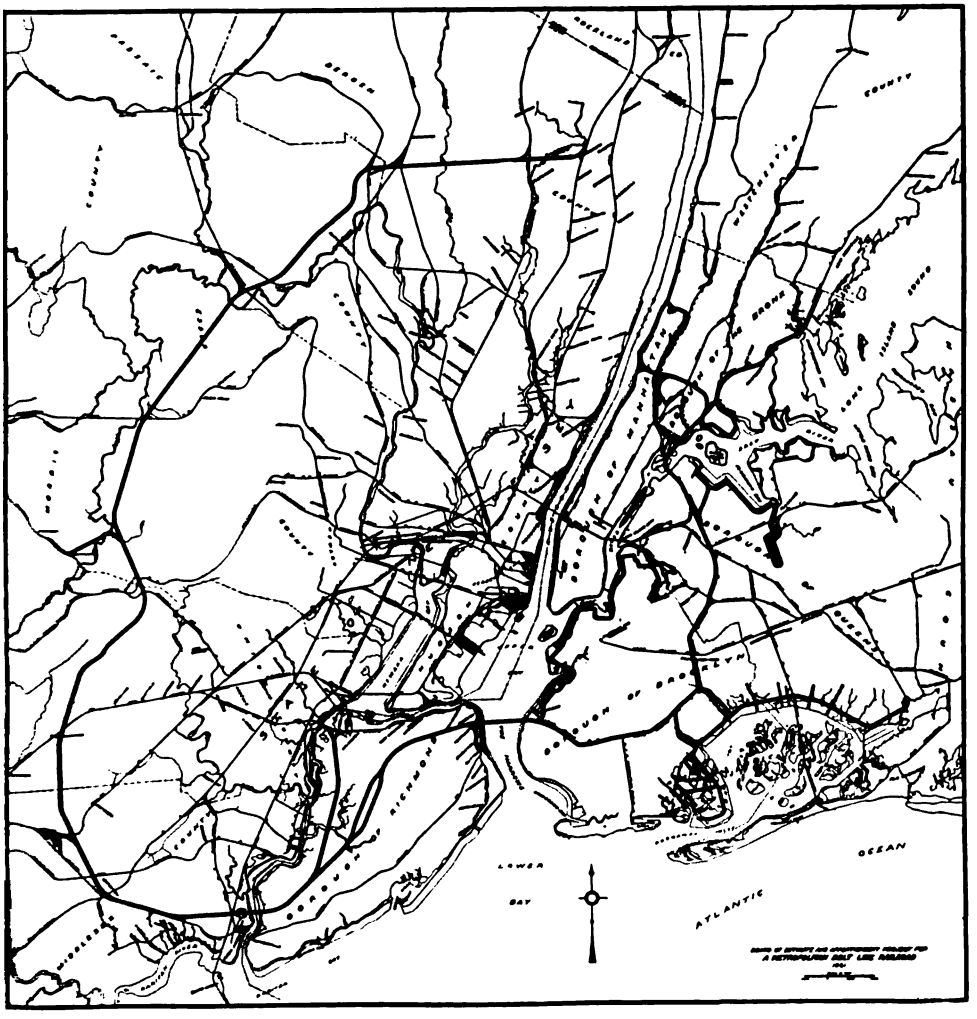

METROPOLITAN BELT LINE RAILROAD PROJECT REPORTED TO THE BOARD OF ESTIMATE AND APPORTIONMENT

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of the construction of the automatic electric system to serve the Manhattan commercial center and has adopted the basic features of the Narrows Tunnel project by the substitution of a tunnel from Long Island as the prime necessity, but in the selection of Greenville as the western terminal and in its projected use of existing lines for trunk interchange, the Port Authority plan carries features which appear so prejudicial to the interests of the entire port in general and to Staten Island in particular, that they should be given serious consideration.

The Arthur Kill water-front of Staten Island, notwithstanding that it possesses great natural advantages, is now and will continue to be dormant until railroad facilities are provided for it, and the City's twelve new piers at Stapleton and the seven adjoining piers of the American Dock Company, with a possible freight development of from 15,000,000 to 20,000,000 tons per annum, or say equal to at least one-fifth of the entire railroad freight and one-third of the total water-moved freight of the port, are left not only disconnected from the other boroughs of the City but dependent for westward traffic upon a railroad, the greater essential portion of which is now and must continue to be incapable of serving as a freight carrier, with no possible chance of securing an eastwardly outlet through Brooklyn as there is not room economically for more than one such tunnel freight line across the bay. Again, the routing of the belt lines in New Jersey to connect with the proposed Greenville tunnel is along trunks already so saturated that their particular needs will effectively shut them out for interchange use on any substantial scale, and, furthermore, such a tunnel depends wholly for successful operation upon the provision of a common classification yard, wherein cars from all lines can be properly assembled and dispatched, no adequate room for which is available under the plan outlined. It may well be asked if an attempt to enforce this plan would not only add to the congestion of the territory adjoining Newark bay and the Hackensack river, a considerable portion of which is now devoted to railroad use.

The principal belt-line features of the Port Authority plan, in so far as they relate to interchange on the New Jersey side, were originally submitted by the Chief Engineer of the Board of Estimate and Apportionment to the railroad engineers and rejected as unworkable, this rejection also applying emphatically to the connection proposed by the Port Authority between the New York, New Haven and Hartford railroad and the New York Central rail-

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road. In fact, it would appear from the information at hand that the Port Authority plan for belt-line railroads could not be expected to actually provide more than a Long Island-New York, New Haven and Hartford railroad connection for the southern tier of railroads in general and the Pennsylvania railroad in particular, and that it does not lend itself to the common use of the remaining roads of the Metropolitan district on a scale in any way adequate to the needs. It has been said that if the Port Authority plan is not perfect when it is adopted, it is still subject to modification from time to time, in reply to which it should be pointed out that the machinery provided in the port treaty for such changes is of a character such as to leave little hope for amendments of an important nature, and particularly if community interests become in any way involved.

It has been rumored within the last few days that in order to overcome the protest set up by the Staten Island interests against its plan, the Port Authority proposes to amend it before submission to the Legislature on January 1, 1922, as it is required to do, by providing for a connection from the belt line in New Jersey to Staten Island by a line crossing the Arthur kill at Tremley Point, it being intimated that this would provide a suitable connection with the proposed City tunnel across The Narrows. Without entering into a discussion of this modification in plan, it may be said that it in no way removes the objections heretofore made, as the construction of the proposed Bay Ridge-Greenville tunnel by the Port Authority would make the Narrows tunnel impracticable on economic grounds, there being insufficient traffic to justify both. In view of the fact that either tunnel is expected to be self-supporting, it might be assumed at first thought that the better plan would be disclosed through negotiations with the railroad interests and that either should stand or fall on this basis, but this is not a fair view of the case since the adoption of the Port Authority plan, notwithstanding what appears to be its lesser advantages, would give it an official standing of such a permanent character as one to be carried out under joint state auspices as to deprive the more comprehensive Narrows tunnel proposition of its present marketable features.

In conclusion, let me say that the Narrows Tunnel project was originally approached by the engineering staff of the Board of Estimate and Apportionment as one which was largely localized, but as the studies have advanced so has also the feeling of assurance that it possesses the essential economic features requisite to the cure of the present evils of port congestion and delay, with their incident

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expenses, and not only without prejudice either to any part of the City of New York or to our neighbors in New Jersey, but also, in a broad and comprehensive way with ample field for unlimited development of the trunk-line railroads to meet the future needs, and with potential possibilities of developing great water-front areas along modern lines which could compete successfully with any other port where rivalry is threatened.

PART II.—By Colonel William J. Wilgus

It is indeed a pleasure for me to have this opportunity of addressing an engineering audience on an engineering subject of such vast importance to the public of which we are a part. For many weeks the press of this City has opened its columns to one-sided propaganda voiced by non-engineers in behalf of plans prepared by the Bi-State port organization for the solution of our cross-water traffic problem. But, so far as my observation has gone, not the slightest effort has been made by this same press to lay before their readers the other side of the case from the City's view-point, in consonance with what we were once pleased to call American fair-play.

An instance of this is the appearance of a flaring statement in at least one of this morning's papers that the City proposes to spend $175,000,000 for a bridge over the Kill von Kull and the railroad leading from it to the Narrows tunnel. This is correct except in two particulars. The proposed bridge is not over the Kill von Kull but over the Arthur kill. The proposed expenditure is not $175,000,000 but less than $12,000,000. It is thus that the public are led astray.

Therefore, actuated by that public spirit which we as engineers are often reproached for lacking, will you not do all in your power to make known to the public those facts, heretofore concealed from them, which they must know if they are to pass intelligently on what so vitally concerns them? Stated differently, will you not as engineers aid your fellow-citizens to a full understanding of a subject on which you are peculiarly qualified to expound? The lawyer or merchant would not idly sit by, should engineers be so foolish as to attempt to guide the public in matters in which he is specially versed by education and experience. Then why should we be silent when the reverse is the case?

The problem before us, briefly stated, is the devising of the best means of handling traffic, estimated at the present time at some

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> In the proceedings before the Interstate Commerce Commission in the matter of rate allowances at New York it was shown that the whole organization of the port fundamentally is wrong and that under the unscientific and uneconomic methods practiced by the carriers, congestion and expense have become normal conditions, and some remedy soon must be found.

It is well here to quote extracts from a few of the many expressions of large shippers along the Brooklyn water-front when interviewed as to their attitude on the building of an all-rail connection with the trunk lines:

> One says that the rail connection would be "of supreme benefit during the winter time. It would overcome delay due to lighterage from New Jersey terminals. In a normal year it takes about ten days on an average to get a car of freight from Jersey over here."
>
> Another states "In the last ten years the port has lost 50 per cent. of possible trade. It has lost its coffee trade to Baltimore and New Orleans. Sugar going through Philadelphia and Baltimore can there be brought in for 35 per cent. of the cost in New York. Nitrates can be imported at Norfolk and Brunswick for 50 per cent. of New York costs. Wood pulp costs 40 cents a ton in Norfolk f. o. b. including labor and 15 days storage, while here it would cost at least $1.00 to be conservative, probably $1.50. Poor terminals drive business out of this port."
>
> Several engaged in the coal trade comment on the great saving that would be effected in re-handlings and consequently in degradation or breakage of coal, and on the possibility of stabilizing the market through storage.
>
> A varnish manufacturer says "substitute turpentine can be bought for 5 cents less per gallon in tank cars than in tank wagons or drums. Present situation threatens to force removal of concerns elsewhere."
>
> A lumber merchant states "I believe the water-front railway is the only thing that will ever develop this section. Material now comes by rail one-third and by water two-thirds,—but if the railroad was put through the proportion would be reversed."
>
> A manufacturer of drop-forgings says "we have been trying to get a car from New Jersey for a week—usually takes a week."
>
> Another manufacturer in forcefully expressing his desire for direct rail service stated "the history of this part of Brooklyn has been that when a plant becomes large it moves to Jersey", at the same time giving concrete examples of such action.

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line at Paris at crucial moments when the saving of a few hours in the dispatch of allied troops to the front made all the difference between victory and defeat.

Is it not, therefore, evident beyond peradventure that inaction is not to be thought of, and that the thing to be done is to determine quickly the way in which to provide for improved cross-water freight and passenger transportation, not alone for the present but broadly for the future to the extent that light may be given us to look ahead?

This being admitted, underlying principles should be adopted for our guidance in planning the proper remedy. Here are the ones that occur to me as having special force:

1. Fixed charges should be minimized as far as is consistent with the accomplishment of the desired purpose, through (*a*) the avoidance of costly duplicate routes, (*b*) the utilization of the City's splendid credit for borrowing the necessary funds at a low rate for this self-supporting public enterprise, and (*c*) the adoption of a route which may be used in common with other public projects so that all may reap the benefit of joint savings in cost of construction.

2. Tonnage to and from Staten Island, Long Island and New England should be routed around rather than through areas in New Jersey that are now or may in the future become congested by reason of their own local freight and passenger development, as for instance between the Orange Mountain range and the water-front.

3. Crossings of rail and water traffic should be separated through the use of tunnels or high-level bridges, so that one will not interfere with the other. Grade crossings of traffic through the use of draw-bridges are particularly to be avoided in this case where the annual rail movement will exceed 20,000,000 tons, and the Arthur Kill water traffic 30,000,000 tons, each several times the Panama Canal movement. The Newark Bay water-borne tonnage also is large and has promise of great future increases if the plans of the Bi-State port organization for the deepening of the channels to Newark, Paterson and Passaic and up the Hackensack river are carried out.

The Bi-State port organization itself said on this subject, at page 345 of its report of 1920: "Here also (Lehigh Valley Railroad and Pennsylvania Railroad crossings of Newark bay) tunnels should be built rather than bridges. The Commission assumes that any crossing of the bay as part of the proposed exterior belt-line system will be by tunnel."

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between the two boroughs mentioned is insufficient under present conditions to make the project self-supporting.

Then how may the law's mandate be obeyed other than by showing to the only possible tenants whose traffic will warrant the payment of an adequate rental—the trunk-line railroads terminating in New Jersey—*first,* how it may be made possible for them jointly to create an outer belt line for connecting them with the proposed tunnel and thence with all boroughs of the City and beyond, and, *second,* why it will be to their interest to do so?

In following this unavoidable course it was necessary that the proposed connecting route should be in strict harmony with the aforesaid principles, and to that end the line proposed by me some ten years ago and placed at the disposition of the New York and New Jersey Harbor Commission through the Federal Government during the war, has been adopted by the City's engineers for the purpose of negotiating with the prospective users of the tunnel, the railroads. The line, with easy gradients, passes westerly from a connection with the West Shore railroad at Haworth on the north, thence back of Paterson and along the rural valley of the Passaic river to a piercing of the Orange mountains near Summit, thence along the foot of the range and through South Plainfield to Perth Amboy, thence on a high-level viaduct over the Arthur kill to Staten Island, thence on a gradual descent through the midst of that island to a new classification and consolidation yard and thence beneath The Narrows to a connection with the Long Island railroad and Brooklyn water-front, beyond which access is had to the Boroughs of Queens, The Bronx and Manhattan and to New England, via the New York Connecting railroad and sundry connections.

This route meets all the conditions that have been mentioned. It involves no duplicate routes, it avails itself of the City credit and it lies where adjoining public facilities may be economically created, as for instance the use of the same trench under The Narrows for rapid-transit tubes and the use of the proposed high-level viaduct between Tottenville and Perth Amboy for a badly needed short-cut for vehicles passing to and from the New Jersey sea-coast. It avoids the congested regions in New Jersey. It passes high over or beneath the navigable waterways. Its gradients west of the electric zone are very light. Its yard on Staten Island serves all the purposes of economical classification and train consolidation and restricts the territory requiring immediate electrification to that lying east of the yard and in so doing relieves the steam railroads from

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it should not be done here, until the time may come in the future when growth of traffic may warrant the laying of additional self-supporting tubes. As to rapid-transit passenger service, it has been expected that tubes therefor would be laid alongside those intended to be created under the present law, and our published plans have so indicated.

The charge that the Narrows Tunnel project is intended to be a local improvement only is refuted (*a*) by the title of the act, which reads "An act to authorize the Board of Estimate and Apportionment of the City of New York to construct a tunnel for freight and passenger purposes under New York bay, between the Boroughs of Richmond and Brooklyn, by improving and increasing the terminal facilities of the City of New York to maintain the supremacy of the Port of New York", (*b*) by the self-supporting provision of the law which compels the City to look beyond the confines of Staten Island for traffic, and (*c*) by ordinary common sense which indicates that the very best results should be striven for in the true interest of the City and the port, even if this does call for negotiations with the only possible users, the railroads. After all, the railroads are national carriers and not the exclusive servants of the state in which their terminals happen to lie. The City does not propose to go beyond its boundaries to reach them—it is merely beckoning to them to come within its midst by means of a new and better gateway under mutually satisfactory terms. For the City to do otherwise would indeed be blame-worthy.

As to the charge, attributed to the Bi-State port organization, that the Narrows Tunnel project is uneconomic, no figures have been produced to substantiate it. If it is true of this admittedly necessary and authorized connection between Brooklyn and Staten Island, then it is true in a much greater degree if applied to the combined Narrows tunnel and cross-bay tunnel proposed by the Bi-State organization. Fortunately for the future of the port and for the City, it is not true.

As to the break-up yard story, a few examples of yardless junctions will dispose of it. On the New York Central a yard of this nature was not found to be necessary at Depew, where trains made up many miles to the east, at DeWitt and East Rochester, split in two directions, one for Buffalo and the other for the west via the Lake Shore and Michigan Southern Railway; nor was one found necessary at Hoffmans, where trains made up at distant DeWitt and destined for New England and the West Shore are diverted from the main line.

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which such principles are aimed. We must remove our disabilities,—not perpetuate them.

If the points as I have outlined them are well taken, as I hope and believe they are, it must be apparent to you, *first,* that there is an impelling need, voiced by all interests, for an improved means of freight and passenger rail transportation between the New Jersey mainland and our City; *second,* that the authorized City Narrows tunnel, connected at both ends with the trunk lines, offers the best solution for four of our boroughs, with a beneficial effect on the fifth, and *third,* that an additional cross-water route, for serving in part the same purpose, will impose on the port and on the City an additional burden of fixed charges for which there is no warrant.

Concisely put, the query is not whether there shall be the Narrows tunnel *or* the cross-bay tunnel, because the Legislature of this State has settled that in favor of the former. It is whether there shall be the Narrows tunnel *and* also the cross-bay tunnel. One is badly needed but not both. Then why not all pull together to make a success of the one that has been actually authorized and which has such outstanding advantages, and make it a complete success? Certainly we should not show a divided front to our rivals, of which the Great Lakes-St. Lawrence project looms large as a possible foe worthy of our steel. Let us show to our mid-western friends that we mean in good faith to remove at least some of our defects of which they rightly complain.

I shall be most happy to respond to any questions that you may care to ask me with a view to clearing up points that I may not have made plain.

PART III.—By Major John F. Sullivan

The general problem demands that actual work be started without further delay because the present condition of the freight terminal and transportation facilities are a menace to the City of New York and threaten the commercial supremacy of the Port of New York.

There is no doubt of the imperative need of co-ordinating the facilities of both sides of the port, which would carry with it mutual advantages.

Nothing practical has been accomplished in the nature of improving the port facilities for many years, with the exception of dock construction, and this is particularly true with reference to freight railroad facilities, with the result that there is at present an enor-

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During the month of August last, when this project was undertaken, the railroad executives and engineers insisted that the City put something concrete before them for their consideration, and with that in mind, there was promptly prepared the report upon which the discussion to-night has been based.

We are still negotiating, and it is my personal judgment that should the railroads fail to see the opportunity now offered them to jointly do something constructive for and with the City of New York, they will lose a wonderful opportunity to gain the confidence of this great community, and that the City should proceed with the construction of a comprehensive terminal system to be operated by a single terminal company.

We have seen the enormous home and industrial development of the Boroughs of The Bronx, Brooklyn and Queens following the expansion of the transit system, and just so we can visualize a similar growth of Staten Island and other communities within the Metropolitan district located on a belt-line system offering the joint service of the railroads of the port.

What This Plan Will Accomplish

It puts the Boroughs of Brooklyn, Queens, Richmond and The Bronx on the back-bone of the trans-continental trunk lines of the United States.

It furnishes adequate facilities for the Boroughs of Brooklyn, Queens, Richmond and The Bronx which may be either supplementary to or independent of any plan for Manhattan borough and New Jersey.

It utilizes the present Hell Gate bridge and the existing lines of the New York Connecting and Long Island railroads in The Bronx, Queens and Brooklyn, in connection with the proposed line under The Narrows and through Richmond to New Jersey to secure a through trunk line.

Eastern Canada, New York and New England will be connected through the City to the south and west by an all-rail trunk line, eliminating lighterage.

It will be possible to handle direct by rail, raw materials and finished products.

Two-thirds of the population and 90 per cent. of the area of the City of New York will be directly benefited by the plan.

Time, cost of operation and delivery, and damage to shipments will be reduced.

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The development of industrial districts with increased business opportunities will be made practicable and new industries encouraged.

Belt lines will serve the industries, terminals, markets and the water-front.

Weather hazard in the transfer by water will be eliminated. Relief of congestion in lower Manhattan will be effected by the diversion of freight *around* instead of delivery *in* Manhattan followed by trucking to the outlying boroughs.

PART IV.—By Jesse B. Snow

The previous speakers of the evening have given you an outline of the port problem and its economic features, as affected by a City-owned tunnel between Brooklyn and Staten Island. It remains for me to discuss briefly some of the engineering features of this tunnel.

This tunnel link presents the most interesting engineering problem of the whole work, and despite public assertions to the contrary, a great deal of study has been devoted to this feature of the project. Discussing the report of the Special Committee of the Board of Estimate and Apportionment, before the Chamber of Commerce of Brooklyn, on October 29, 1921, Governor Miller said, according to newspaper reports: "Why! the City has not made its borings for this tunnel that this Commission of Engineers was created to study. The fact is that they did not study the tunnel project."

The facts are that between August 9 and October 14 when our report was presented to the Chief Engineer, we had studied eight different crossings of The Narrows and these eight crossings, together with variations in the land approaches, led to the study of thirty different lines and the preparation of complete detailed estimates of the cost of construction and equipment for all of them.

General Introduction to the Problem and Explanation of Determining Conditions.—It must be borne in mind that the construction of any tunnel under The Narrows is limited to about two miles of shore front, extending in Brooklyn from 67th street on the north to 95th street on the south, and in Staten Island from St. George on the north to the United States Government reservation on the south.

From a study of the borings made by the Board of Water Supply in 1907, previous to the construction of the Narrows siphon, and

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those made by the Pennsylvania railroad in 1892, when they were considering the construction of a railroad tunnel at this location under The Narrows, it appears that the tunnel will be constructed in soft ground, except in Staten Island and possibly for a short distance in Brooklyn. The preliminary borings which we have taken in Staten Island show that the tunnel will be constructed through mica-schist for several hundred feet west of the bulkhead line, and then through serpentine rock practically all of the way to the portal.

Any route selected for a tunnel under The Narrows, to be used for freight purposes, should connect with the Long Island railroad in Bay Ridge. This fixes the location of the Brooklyn end of the tunnel. The problem, therefore, is reduced to the determining of the most economical line from a construction and operating point of view on which The Narrows can be crossed, bearing in mind the classification yard and the connection that must be built to the trunk-line railroads in New Jersey. The classification yard will require a large amount of ground and should be located in the most suitable district for railroad operation and so as not to interfere with the development of the surrounding territory. The location selected near the center of the island is adjacent to territory which, in the future, it is expected will be largely given over to industrial purposes.

Before laying out lines to be studied for the Narrows crossing, we conferred with the United States district engineer in whose jurisdiction the tunnel would be located, for the purpose of ascertaining what limitations would be imposed by the War Department as to the depth below mean low water at which the permanent structure must be built. We were told that the conditions required by the War Department would be about as follows: That no part of the permanent structure between the pier-head lines, as established by the Secretary of War, should be above a plane situated 50 feet below mean low water, and that all temporary structures should be removed to that depth.

Routes Studied.—A contour map of the bottom of The Narrows was then plotted from data given on the anchorage chart of New York harbor, and with the governing locations for termini in mind, eight different crossings were then selected and profiles of these lines plotted. Variations in the land approaches to these crossings led to the study of fifteen routes. Most of these routes were studied

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and estimated for both 1-per-cent. and 2-per-cent. grades in both Brooklyn and Richmond. The 2-per-cent. grade was taken as the maximum from practical operating considerations. These estimates show that in all cases the cost of the tunnel on a 1-per-cent. grade was so much in excess of that for the 2-per-cent. grade that the saving in operating cost on a 1-per-cent. line did not warrant its adoption as a maximum grade, and the studies were therefore narrowed down to the 2-per-cent. grades.

In the laying out of these routes, the desirability of long tangents and the minimum amount of curvature was kept constantly in mind, as well as the locations for classification yards. Studies were also made to provide connections to the Stapleton piers and the suggested industrial railroad along the Brooklyn water-front.

After estimating the construction and operating costs of these lines, the effect of the various routes upon the development of Staten Island and the Port as a whole were considered, and the route from 67th street, Brooklyn, to Arrietta street, Staten Island, was finally selected as the one to be recommended to the Board of Estimate and Apportionment.

The question has been raised as to the depth of water in The Narrows being so great as to make impracticable the construction of a tunnel there. The depth of the tunnel below water is determined by the requirements of the United States Government. Under these requirements, the maximum depth of the base of rail in the proposed tunnel is 83 feet below mean low water. Depths in other soft-ground tunnels are as follows:

Pennsylvania North River tunnel	89 feet.
Pennsylvania East River tunnel	82 feet.
Old Slip-Clark Street tunnel	82 feet.
Whitehall-Montague Street tunnel	76 feet.
14th Street-North Seventh Street tunnel	88 feet.
60th Street tunnel	109 feet.

It will be seen from the above that the depth of water presents no difficulty which has not already been overcome in the construction of other tunnels. The construction of tunnels under rivers and harbors develops many difficulties, but from experience gained in the construction of other subaqueous tunnels in the vicinity of New York and elsewhere, it is certain that the successful completion of the tunnel under The Narrows can be assured.

In the construction of subaqueous tunnels, three methods have been used as follows:

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1. The shield method;
2. The trench method;
3. The caisson method.

Shield Method.—The shield method has been used in the construction of practically all of the subaqueous tunnels in New York City. In the crowded waters of New York harbor, this method offers the great advantage that all tunneling operations are conducted under the bed of the river without obstructing the water-way.

In this method of construction, the tunnel is built within the protection of a cylindrical shield which is pushed ahead of the portion of the tunnel already built, and serves as a protection for the men carrying on the excavation and building the tunnel lining. The lining consists of successive cast-iron rings, each ring being made up of segments bolted together. In the tunnel here proposed, each ring is made up of eleven segments approximately 6½ feet long and a key one foot long. The rings are 2 feet 6 inches wide. In each ring there are 67 bolts on the circumferential joints and 60 bolts on the horizontal joints. The diameter of the bolts is 1¾ inches. The weight of the cast-iron lining is approximately 5 tons per linear foot. Inside the cast-iron ring there is an inner lining of concrete. This lining is introduced to protect the flanges from any damage in case of derailment of a train and to minimize the seriousness of the wreck by providing a smooth surface which will not catch the derailed cars; also to provide a permanent protective coating to the entire structure.

Trench Method.—The trench method of tunnel construction of comparatively recent date, has been used in the building of several tunnels, notably those under the Harlem river for the New York subways and under the Detroit river for the Michigan Central railroad. The work is conducted from a floating plant in the river and the tunnel is either constructed in a sheeted trench under a protecting roof, or floated into position and sunk in sections in a dredged trench.

The Detroit River tunnel for the Michigan Central railroad is the longest and largest subaqueous tunnel which has been built by this method. Colonel Wilgus, who has spoken to you to-night, was Chairman of the Board of Engineers who had charge of the construction of that tunnel, and the preliminary plans for it were prepared under his immediate supervision. This tunnel consists of water-tight twin steel tubes with an inner lining of reinforced

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There has recently been given to the public by the Port Authority a map showing belt lines and river crossings proposed by them. With slight modification, the outer belt line is the same as was recommended in the Bi-State Commission 1920 Report and in the Special Committee's report of October 15, 1921. This belt line was studied by Colonel Wilgus in 1906 and by the speaker in 1918. The Port Authority's map also shows a number of inner belt lines which appear to contemplate the use of existing railroads. The use of some of these lines was proposed by us in our early conferences with the chief engineers of the New Jersey railroads, but they pointed out that on account of the heavy traffic passing over these lines at the present time, it would be impracticable to use them for belt-line purposes. This is especially the case with that portion of the Central Railroad of New Jersey between Elizabethport and their northerly crossing of the Hackensack river, which is apparently a link in the middle belt line proposed by the Port Authority.

It has also been stated that the tunnel from Greenville to Bay Ridge is but little longer than the tunnel proposed by the engineers of the City. As to the total length of the tunnel, this may be true, but the under-bay section between pier-head lines, which involves the most costly type of construction, is about 4,000 feet longer than the corresponding part of the Narrows tunnel, so that the cost of the tunnel proposed by the Port Authority would be considerably greater than the cost of our tunnel.

Some preliminary borings have been made in Staten Island, and a contract for borings along the entire route will be advertised shortly. Meanwhile, topographical surveys are under way and the preparation of contract drawings is in progress.

The project has passed the preliminary stage and now that the plans of the Port Authority have been made public, our previous judgment is strongly confirmed that the Narrows Tunnel project offers the best solution of the problems of the entire port district that has yet been put forth, and it is hoped that nothing will deprive the port of the great boon of improved railroad facilities which will be provided by the construction of this tunnel, which is not a paper scheme to be developed some time in the future, but one upon which work is actually under way and which offers the port the best and speediest relief from its congested and antiquated methods of operation.

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Abstracts from the Discussion

PRESIDENT FARLEY, in opening the meeting to general discussion, called upon former Borough President GEORGE CROMWELL of Richmond, who in reply referred to the early history of negotiations looking toward a physical connection between the Boroughs of Richmond and Brooklyn and his own active efforts in that direction. He urged that the best features of the three plans be selected, that they be merged in the best interest of all concerned not alone the people of New York City but the entire country.

COLONEL WILGUS (the Author) (replying to a question by NELSON P. LEWIS,* M.M.E.N.Y., who arose in response to President Farley's invitation).—As I understand Mr. Lewis' queries, one deals with the best means of creating the Arthur Kill bridge, which of course will be an interstate structure; and the other refers to the handicap that the northern group of roads would be under in having a longer haul by the belt line.

As to the necessary legal procedure in order to make possible the construction of the Arthur Kill bridge. Unquestionably there would have to be special legislation unless the work is done by existing Bi-State agencies. As I understand it, the New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission were authorized or directed a year ago to make an investigation, with a view of determining how a bridge might be created across the Arthur Kill or across the Kill von Kull, but owing to the non-appropriation of funds, nothing has been done. The fact remains that there is and has been an urgent desire for the bridge, and we have felt that by showing how the proposed railroad structure may be built in such manner as to accommodate the highway the two states might see the opportunity and seize it. The part chargeable to each character of usage would thus be much less than if each is provided for separately. So that, from the very fact that there is a public demand for such a joint passage, we have felt there would be no difficulty in securing the necessary legislation by both states.

As to how the cost would be divided, that remains a matter of negotiation which is now under way with the railroad companies. A separate company might be organized under conditions that would bring both the railroads and the City to participate in the

* Formerly Chief Engineer, Board of Estimate and Apportionment, New York City.

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cost, so that the City's share on the east side and the railroad's on the west side of the center line of the Arthur Kill would be equitably determined. Nothing in this seems outside of the bounds of reason, because of the necessity for such a structure and the fact that the legislatures may be expected to respond to the call of public interest. I may say that such sketches as we have made so far and have estimated upon, demonstrate the feasibility of creating a strikingly beautiful as well as a useful structure for this dual purpose. The railroad would not only pass over water-borne commerce without the necessity of interruption to either, but also the highway would pass over it with a minimum of interruption. Existing highways in Staten Island and New Jersey admirably lend themselves to this idea, not the least of the advantages of which will be a saving for automobilists of some 14 miles distance between Manhattan and the New Jersey sea-coast.

Such investigations as have been made of the business of the present little ferry-boat between Tottenville and Perth Amboy, would indicate that the interest charges on the portion of this structure chargeable to the highway, would be much more than met, even with the present traffic, not taking into account the increase that would flow from the more convenient and time-saving improvement. It has been demonstrated in the case of the New York-New Jersey Vehicular Tunnel project how improved vehicular access may be made financially attractive through tolls, and our investigations indicate that this will be equally true at Perth Amboy.

Now as to the added length of haul for the northerly group of railroads. That is a fact. On the other hand, it is believed that this will be much more than overcome by the savings that will result from the avoidance of congested water-front terminals and water-carriage on the existing routes. An added length of haul is justifiable on railroads where the savings in time and cost of operation are sufficient to justify the building of new routes. In the past we have had to deal with many problems of this kind where the wisdom was proven of abandoning a direct route with heavy gradients and sharp curves in favor of a more circuitous valley, and therefore longer route, having lighter gradients and easy curvature. Added length of route is not necessarily a handicap. Coupled with this explanation, there is the further one that here is the logical and proper place for utilizing the joint operation idea that has proven to be so successful at St. Louis, through the organization of a joint operating company to be known as the Metropolitan District

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matter. COLONEL WILGUS, however, pointed out that the trunk-line passenger traffic problem was one that must be faced, and faced emphatically, in the future.

A GUEST.—I have been wondering to what extent the plans you are contemplating recognize the existence of the New York State barge canal and the necessity of connecting up in some way with the barge canal traffic?

COLONEL WILGUS.—I am glad that you raised that point. The plans for the Narrows Tunnel route contemplate direct rail connections and access to every place on the City of New York waterfront that can be reached. The Arthur kill and the Kill von Kull, which handle something like 30,000,000 tons per annum, are admirably situated for development on the New York side now neglected. The same thing is true in the Jamaica Bay region. Of course the Stapleton district is already well advanced toward complete development. There are the Flushing Bay, Hunts Point and Harlem River sections, all of which will be brought directly in contact with the nine trunk lines of the port by means of the route we are discussing. All will be available for interchange of freight with the barge canal. It has been very distinctly had in mind that every one of these points will be accessible for canal traffic.

A MEMBER.—Is it not a fact that under the authorization of the Smith bill, a lessee of this project must be provided practically before construction?

COLONEL WILGUS.—I do not understand that to be the case. Under the act it is by no means necessary, but it is desirable.

A MEMBER.—Is there any prospect of a reply from the railroad engineers in the immediate future?

COLONEL WILGUS.—Yes.

ROBERT RIDGWAY,* M.M.E.N.Y.—(replying to a request from President Farley).—All I can say is that I wish something could be done to bring the members of these various commissions

* Chief Engineer, Transit Commission, New York City.

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CORNELIUS G. KOLFF.*—Colonel Wilgus and Mr. Lewis both stated that a fundamental principle in the development of great ports all over the world has been that the great terminals should be absolutely under the control of the municipality and not under the control of any one railroad or set of railroads. It has been my dream, and the Staten Island Chamber of Commerce has adopted it at its meetings over and over again, that the terminals of New York harbor should be under the control of the municipality. The tunnel under The Narrows is but a link in a great chain, the vital artery connecting the whole scheme, and if you lease it to a railroad, won't you defeat the very object that has been had in mind? It seems to me that the entire system should be under the control of the municipality.

COLONEL WILGUS.—I would like to say in response to the very pointed thought just uttered, that when we first started this study, personally I had in mind, as Mr. Tuttle will testify, the use of a route of this kind as a municipal railroad, similar to the one that has operated successfully in New Orleans, and likewise at other important points on this continent, as for instance at Philadelphia, San Francisco and Montreal. An alternative was the leasing to a railroad terminal association of the kind that I have previously referred to, in which not one but all railroads would be joint lessees, with an agreement that the service would be performed, as to quality and price, under conditions that will be satisfactory to the municipality and commercial interests, thereby giving the municipality all the advantages that could come from ownership, without the necessity of entering a field for which it is not qualified. The idea of leasing to one or any group without proper restrictions has not been thought of.

* President, Chamber of Commerce, Staten Island, N. Y.

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13 Traffic
Control

Paper 132

PRESENTED MAY 24, 1922

THE CONSERVATION OF EXISTING FACILITIES FOR THE RELIEF OF TRAFFIC CONGESTION

BY AMOS SCHAEFFER,* M.M.E.N.Y.

WITH DISCUSSION BY CHARLES U. POWELL, PHILIP P. FARLEY, DANIEL L. TURNER, HARRY N. LATEY, HENRY W. VOGEL AND THE AUTHOR

Congestion of traffic exists in spots and not throughout the City, or throughout a borough, nor even throughout any considerable portion of the Borough of Manhattan. When remedies for the relief of traffic are applied, therefore, it is not necessary to duplicate north and south thoroughfares by laying out new avenues. This kind of treatment will not be required for some time if the City will exercise to the fullest extent the police power conferred upon it in the zoning law when planning future transportation facilities.

This discussion will be confined to improvements which may be made to existing structures to increase their capacity to accommodate traffic rather than to the regulation of traffic, although these two functions are so closely related that it is not always possible to keep them separate.

ZONING AND TRANSPORTATION

Until the zoning resolution was adopted by the Board of Estimate and Apportionment in 1916, there was nothing to prevent the erection of a building to almost any height in any part of the City and to use it for any purpose. The result has been a promiscuous use of buildings for manufacturing, business and residence in many parts of the City, but more particularly in the lower part of the Borough of Manhattan. We have not only the densest residence population in this section of the City but it is also the most intensively used for manufacturing and business. This natural, or per-

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haps unnatural, development had been so long uncontrolled that ever since additional rapid transit facilities became imperative in 1900 every line had to pass through lower Manhattan to carry people to and from their work and business in this section of the City. As time went on this condition became intensified, in fact all rapid transit lines today, both existing and proposed, are destined for lower Manhattan except one which has just been proposed as a cross-town line in Brooklyn and Queens.

The time is rapidly approaching when all streets will be occupied by subways and no more can be built in this part of the City. The question naturally arises as to how much longer this plan of rapid transit development can continue. There is no doubt that there is a limit to subway construction in the streets in lower Manhattan. On the other hand, the limit in density of factory and business population will not be reached for many years. In other words, the potentiality for increasing the day population in lower Manhattan is much greater than the possibility of increasing rapid transit facilities. It would seem, therefore, that thought should be given to this situation with the idea of directing certain kinds of business and manufacturing to other parts of the City. This is a problem which might well receive the consideration and thought of the Sage Foundation as a part of its program for a "Plan of New York and its Environs" which was made public at the Engineering Building recently.

Prior to the adoption of the zoning resolution there was absolutely no control of the use of property. The Tenement House Law and the Building Code only needed to be obeyed. A property-owner had the right to build a boiler-shop next to the finest residence on Fifth avenue, or a pickle factory on Riverside drive. By reason of this wide-open use of property for all purposes, certain portions of the City had a very promiscuous development at the time the Zoning Commission started its work. New York was the first city in which an attempt was made to control the use, height and size of buildings, and, consequently, the work of the commission was pioneer in character, the way had to be blazed, districts had to be designated in which manufacturing, business and residence might be carried out, respectively, and there was no precedent to rely on in making these determinations.

The main objects of the commission were to provide public safety, public health, public comfort and convenience and to stabilize property values. Under the heading of public comfort and convenience

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parison. This is not the result of zoning, but the large unrestricted and business areas shown on the zoning map are the result of conditions which existed at the time it was adopted, and since the zoning law is not retroactive it can only prevent the promiscuous use of property in the future.

The relation between these uses of property in lower Manhattan and the transportation of passengers was not as apparent then as it is now. A comparison of the map (Figure 1) showing the rapid transit lines in this part of the City on one side and the use districts of the zoning resolution on the other, shows that the greatest number of rapid transit lines appear on the same portion of the map where the greatest number of dots and black lines appear on the zoning map. The dots represent unrestricted, the solid black, business, and no marking represents residence use. Instead of the rapid transit development following this unrestricted and business development in lower Manhattan, steps should be taken immediately to encourage the spreading of both manufacturing and business throughout the outlying sections of the City where cheaper land and better facilities may be obtained under better sanitary and sociological conditions. The area of both the unrestricted and the business uses should be decreased and the residence areas should be enlarged and more should be established.

Even though zoning restrictions are not retroactive, the prevention of the use of additional property for manufacturing and business purposes and the consequent development of new areas at points more remote, where these activities can be carried on under better conditions both as to health and convenience, will eventually remove all of them from the more congested districts and make the latter available for homes under better conditions than now exist generally in lower Manhattan; industries and business will go to localities which are fashionable for their purposes just as individuals desire to live in fashionable social localities. The garment trades have been following closely upon the heels of the retail dry-goods business, for what reason is not apparent, until finally the latter as a matter of self-protection prevailed upon the garment trade to locate elsewhere. They are now located on Seventh avenue and to the west thereof just below 42nd street. There is no reason why these trades should not be located in Queens or The Bronx or some other borough where land is cheaper and where more space could be occupied and where working conditions would be better.

There seems to be an idea that clothing must be manufactured

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where it is sold. The salesroom, therefore, determines the location of the factory. This is not so in other trades and, consequently, it is not clear why the salesroom and the factory need to be under the same roof in the garment industry. The operatives generally live on the east side or use the east side rapid transit lines to and from their homes in the other boroughs, as a result of which the cross-town streets are congested with pedestrian traffic and the rapid transit lines with passengers. The garment industry has been referred to as an illustration and not as the only case of this kind. If these factories were located in other boroughs the operatives would not need to be carried into Manhattan in the morning and out at night. Many of them could live near enough to their work to walk to and from it. The localities vacated by these industries in Manhattan could be reclaimed for residence purposes and occupied by those whose business or work is near at hand. In other words, if industrial, business and residence districts could be scattered more or less uniformly over the entire City, not only would the passenger traffic decrease but fewer subways would need to run through lower Manhattan.

It is realized, of course, that not all industrial and commercial activities could be distributed throughout the City as indicated; for example, the financial district could hardly be moved in whole or in part, neither could the law business be moved far from the courts and governmental centers where most of this kind of business is transacted. It is desirable, for example, that the wholesale dry-goods business should be transacted in one locality for the convenience of buyers, but there is no good reason why retail dry-goods shops should not be distributed throughout the City. It is even conceivable to have several "white light" districts so that everybody would not have to go to Times Square to attend the theatre and get a bite to eat afterwards.

This kind of revision of the zoning resolution cannot be made by the Board of Estimate and Apportionment for lack of time, but a special commission which could give it all the time which it requires should undertake the work.

While the foregoing may be a little beside the point in a discussion of local traffic congestion, the development and use of private property have such an important and far-reaching effect upon rapid transit, as well as upon surface traffic, both as to cost, comfort and its physical development, that the opportunity could not be lost of pointing out the relationship.

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Public Highways

Public highways are acquired and held in trust for the use of all the people for the conveyance of persons and property from one place to another. The abutting property-owner has a right to the street for light, air and access, but he has no private rights in it. He has no right to use any part of it for his private enjoyment or for business. There are many illegal uses and abuses of the public highways which contribute largely to congestion. Under the right of access an abutting owner will use the sidewalk illegally to conduct his business, by displaying his goods or loading and unloading them to the exclusion of the public to use both the sidewalk and the roadway for the purpose for which they are intended. Many property-owners maintain obstructions in the public highways in the form of projections to their buildings, such as bay windows, stoops and areaways. The courts hold that these are not public, but private, uses of the highways and constitute a nuisance and may be ordered removed by mandamus. The courts go further and hold that no public official, body nor even the state legislature may permit such a use and that any permits issued for such purposes are without effect and void.

Widening Roadways

The most widely distributed intense traffic exists in what is generally known as the shopping, theatre and hotel district the centre of which is probably Fifth avenue and 42nd street. For the past twelve years relief has been given generally throughout this locality by removing encroachments and widening roadways. This work has been steadily going on so that with a few exceptions the cross-town streets have been widened between Madison and Seventh avenues from 30th street to 59th street. Portions of Fifth, Madison and Lexington avenues have also been widened. One of the first, and probably the one which gave the greatest immediate relief to traffic, was the widening of the roadway of Fifth avenue from 40 feet to 55 feet. The sidewalks were reduced from 30 feet to 22.5 feet. Before the widening, 15 feet was used for private purposes and the spaces were enclosed and planted as flower gardens or used for other purposes. Many buildings had very costly encroachments in the form of stoops, bay windows and ornamental walls enclosing the spaces used privately. There was a general protest from one end of the avenue to the other against the widening, but imme-

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diately upon the completion of the work everybody, including the abutting owners, recognized the great benefit which had been accomplished.

It may be of interest to know a little about the details of widening roadways. It has been stated already that there is no authority to permit encroachments of any kind in the public highways, nevertheless, there are many encroachments both above and below the sidewalks, all of which, however, are illegal. Vault privileges are granted at initial payments ranging from 50 cents to two dollars per square foot. No payment has ever been demanded or paid for encroachments above the sidewalk; although the courts have held that a property-owner may continue to occupy a vault until the space is needed for a public use, in view of the sweeping decisions as to encroachments there is grave doubt as to the legality of encroachments below the sidewalk. They do not, however, interfere with the movement of traffic until the space is needed for the construction of rapid transit subways or the widening of roadways, and then they must be removed to the extent needed, at the cost and expense of the property-owner.

It has been more recently the policy of the Borough President's office to widen roadways only at such times when it is necessary to repave. This involves only one tearing up of the street. The City makes the necessary appropriation to set back the curb and to pave the widened roadway area. The property-owner is required to remove the encroachments both above and below the sidewalk and to pay the cost thereof. He is required to vacate only sufficient space below the sidewalk to permit the setting back of the curbs to obtain the required roadway widening.

The amount of widening, of course, varies, depending on the number of lanes of traffic that are to be provided for. Nine feet has been accepted as the minimum width necessary for one lane of traffic on wide thoroughfares. The roadway of Fifth avenue was widened from 40 feet to 55 feet, providing sufficient space for six lanes of traffic. Madison avenue was widened from 42 feet to 54 feet north of 42nd street, where there are car tracks which occupy a width of about 20 feet including the car overhang. This widening provided a clear space between a car and the curb of 17 feet. While this is one foot less than nine feet each for two lanes of traffic, it must be borne in mind that these conditions prevail only when vehicles pass a surface car, and also that there are very few vehicles moving in the lane next to the curb. Traffic counts show that where two

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lanes of traffic are moving in each direction the lane next to the curb carries only from 10 to 16 per cent. of the total traffic as against 84 to 90 per cent. for the second lane. This is due to several causes, but largely to the parking of cars at the curb. Motorists avoid driving near the curb because slow-moving vehicles usually use this portion of the roadway and because the slope of the roadway is greater near the curb, increasing the danger of skidding.

On 60-foot cross-town streets the roadways are usually widened two feet on each side. At first thought, this relatively small amount of widening seems hardly worth the trouble and expense involved. The standard width of these roadways is 30 feet and that of the sidewalks 15 feet. The stoops usually encroach on about one-half the width of the sidewalk, leaving only seven or eight feet for the use of pedestrians. There is usually a full line of parked automobiles standing along the curb. The width of roadway occupied by each line of standing cars is about seven feet. This leaves only 16 feet for two lanes of moving vehicles which is two feet less than is provided on thoroughfares which accommodate four or more lanes of traffic, whereas a greater width is required per lane for a small than for a large number of lanes of traffic. In order that proper freedom of movement may be provided in these streets the roadway is widened two feet on each side, making a total width of 34 feet. This provides 20 feet for two lines of moving vehicles between vehicles standing at the curbs, which is ample. Two or three feet more would not help traffic and would rob the sidewalk of that much space. To provide space for an additional lane of traffic would not help the situation because the movement of an odd number of lanes of traffic in opposite directions would cause confusion. The reduction of the width of the sidewalk by two feet is more than compensated by the removal of encroachments which provides a clear space for pedestrians on the remaining 13 feet as against a clear width of seven or eight feet before encroachments were removed. While there is always more or less opposition to the widening of roadways on the part of property-owners, the results have been so gratifying that everybody was thankful it was done.

One of the causes of congestion of traffic is the parking of automobiles. This privilege is abused by many who drive their cars to business in the morning and back to their homes at night, leaving them in the streets all day. This is not a public but a private use of public highways. The man who drives his car to business ought to keep it in a garage during the day and not in the street.

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The loading and unloading of merchandise across the sidewalks likewise is a private use of a public highway. The City cannot provide space for such purposes and the time is not far distant when these uses must be discontinued in favor of traffic which is the proper use of highways. Some merchants have realized this and have already provided themselves with space in their own buildings for this purpose.

34TH STREET, BROADWAY AND SIXTH AVENUE

Practically at every point where Broadway crosses an avenue there is more or less congestion of traffic. Perhaps the most congested of these points is at 34th street. This congestion is caused by the concentration at one point of traffic from three important thoroughfares. At every intersection of Broadway and an avenue there is also an important cross-town thoroughfare, namely, 14th street, 23rd street, 34th street, 42nd street, 72nd street and so on. At most of these intersections the combined width of Broadway and the avenue is not greater than the width of one, namely, 100 feet. This condition, together with the large cross-town traffic, is responsible for the congestion at these points. At 34th street, Broadway and Sixth avenue the subway and elevated station entrances and the elevated railroad columns add to the confusion and retardation of traffic. The Borough President has just presented a plan (Figure 2) for relief to the Board of Estimate and Apportionment (Figure 3 shows existing conditions). After a careful study of traffic observations, and the various structures the conclusion was reached that vehicular traffic was the most congested, and surface car traffic the least. Pedestrian traffic also requires relief, particularly on the west side between 33rd and 34th streets.

Traffic observations show that it takes a surface car 12 seconds to clear the diagonal crossing of the tracks on Broadway and Sixth avenue and that the Broadway and the Sixth avenue cars cannot cross 34th street simultaneously, but that the cars on one line must wait until those on the other have crossed, in other words, the four tracks crossing 34th street have no greater capacity than two tracks provided the tracks are so arranged that the cars on both Broadway and Sixth avenue may get in line before crossing. If it be assumed that a surface car will require 12 seconds to cross the 34th street tracks, which throws the error on the side of safety since it requires but 12 seconds to clear the longer diagonal crossing, five cars could cross the 34th street tracks in a minute in each direction.

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Observations show that during the hour of maximum traffic an average of but 1.6 cars per minute cross 34th street, so that two tracks have about three times the capacity required for surface car operations at present. Furthermore, the surface car traffic is not as dense as it has been and there is reason to believe that it will be still less in the future, in fact, it is predicted that the surface car tracks will be removed entirely; this would increase the capacity of highways in which car tracks are located more than anything else that could be done.

The plan submitted to the Board of Estimate and Apportionment also provides for relocating four elevated railroad columns which stand in the traveled way of 34th street, and the removal of one on the east side of the tracks at about the intersection of Broadway

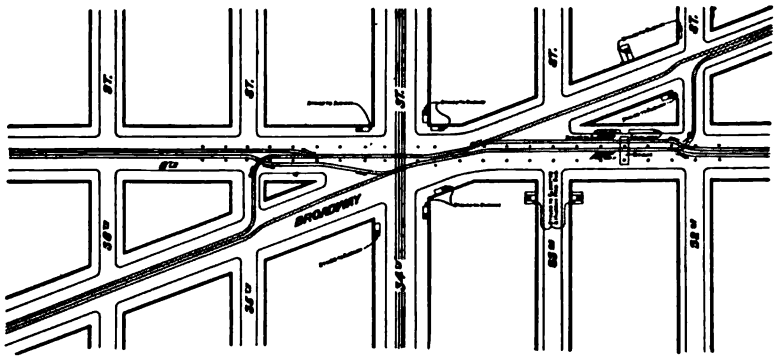

FIGURE 2—PROPOSED RELOCATION OF SURFACE CAR TRACKS AND ELEVATED RAILROAD COLUMNS WITH RESPECT TO STREET AND CURB LINES.

and Sixth avenue which also stands in the line of traffic, and for the support of the cross-girder on a truss spanning between the two adjacent columns to the north and south respectively. In order to give the maximum relief about five columns on the easterly roadway should be removed and relocated on the sidewalk. There is a subway entrance on the Broadway side at the southeast corner of 34th street in front of which the sidewalk space is not of sufficient width to accommodate a column so that the cross-girder at this point also would have to be supported on a truss spanning between the adjacent columns to the north and south, respectively.

The changes proposed in the surface tracks will permit the removal of the outside tracks on both Broadway and Sixth avenue between 32nd and 35th streets and make this space available for

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vehicular traffic. The north-bound cars on Broadway will continue on Sixth avenue and return to Broadway through 35th street which is a west-bound street. The south-bound Broadway cars will run on Sixth avenue to 32nd street and then return to Broadway; 32nd street is a one-way east-bound street. It may be necessary to locate the proposed tracks on 32nd street and on 35th street on one side of the roadways so as not to interfere with vehicular traffic. This can be done by encroaching upon the sidewalks fronting on the two small parks which are not used very intensively. The relocation of these tracks may effect the franchise which the City will probably be willing to modify so as not to impair the railroad companies' rights.

The crossing of the Broadway and the Sixth avenue tracks at

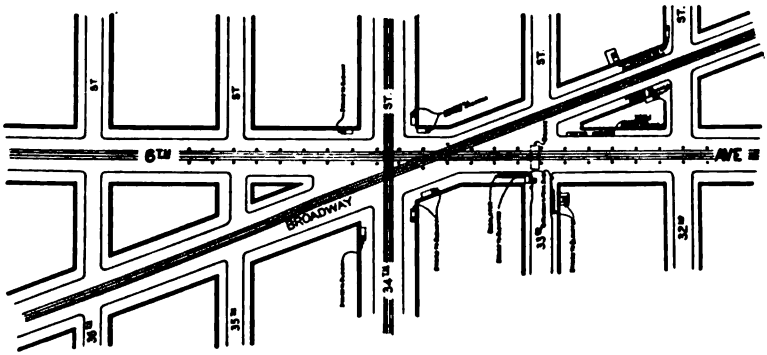

FIGURE 3—PRESENT LOCATION OF SURFACE CAR TRACKS AND ELEVATED RAILROAD COLUMNS WITH RESPECT TO STREET AND CURB LINES.

present is just south of 34th street. In the proposed plan these crossings must still be maintained but they will be moved as far away from 34th street as possible so as not to affect the time of crossing 34th street; one crossing is at 32nd street and Sixth avenue and the other at 35th street and Sixth avenue. There will be running switches both north and south of 34th street, respectively, but they will turn automatically and consequently will not require any attention or cause any delay.

The plan further provides for the removal of all the railroad entrances, both elevated and subway, on the westerly side of Sixth avenue at 33rd street. Entrances have already been made both to the Manhattan and Hudson railway and to the elevated railroad through Gimbel's store and from the elevated railroad to the Saks

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store and there is no reason why the Hudson and Manhattan entrance on the northwest corner should not be put in the Saks building also. Gimbel Brothers appreciate the value of clear sidewalk space in front of their building and are ready to negotiate with the City or the railroad companies for facilities through their store so that the entrances may be removed entirely from the sidewalk.

The Corporation Counsel points out that the elevated railroad franchise probably did not contemplate the use of the public highways for station purposes since it authorizes the company to acquire private property for this purpose. He also holds that the franchise authorizes structures only in the street or avenue which forms a part of the route and not in intersecting streets and that therefore, any structures in 33rd street are illegal. This whole matter is now before the Transit Commission with a request from the Board of Estimate and Apportionment that the structures be ordered removed from the sidewalks and relocated as the commission may direct. There is some prospect, therefore, of bringing about the desired changes.

Attention is called to the number of subway entrances which are located on the sidewalks throughout the City. It has been apparent for many years that the congestion of pedestrian traffic on the sidewalks in the central portion of the City is very great. A proper regard for these conditions should have suggested the location of these entrances on private property. While the Rapid Transit Act declares the construction of subways a proper use of public highways, it does not contemplate taking, for the use of subways, those portions of highways which are already used entirely or nearly to their limit for public purposes, particularly when it is apparent that the space taken for subway purposes must be replaced. The City authority charged with the care of the public highways has always contended that space, already used practically to its limit, should not be taken for subway purposes, thereby compelling the acquisition of additional space to replace that taken for subway purposes. The designers of the subways have taken space already used to its capacity to save the cost of acquiring additional land, against the protests of the City authorities, because the Rapid Transit Act gave them authority to take it.

There is but one point to this whole controversy, namely, who shall pay the bill. If the acquisition of rights to locate entrances on private property is charged to subway construction the expense may be recovered from the proceeds of subway fares; if the City

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has to acquire these rights the taxpayers foot the bill. Once a subway structure is completed, it costs very much more to reconstruct it in a new location than it would have cost originally. The Transit Commission and its predecessors have always taken the position that any expense incurred to replace space taken for rapid transit purposes was for the purpose of improving traffic conditions on the highways and not for improving subway operation and, consequently, it was not a proper subway charge. The time is coming soon when some of these entrances must be located on private property in order to restore the sidewalk space to its original use and the expense should logically be a subway charge.

Fifth Avenue and 42nd Street

For a long time the peak of north and south bound traffic has been at 42nd street, generally speaking, and Fifth avenue has accommodated the largest number of vehicles. The speed of this traffic for a considerable distance to the north and to the south of 42nd street is, therefore, determined by the speed at which it can cross 42nd street. Many suggestions have been offered for relief at this intersection, the most promising of which, for giving the greatest measure of relief, is to depress a center roadway on 42nd street under Fifth avenue. It is believed that there is sufficient room between the subway roof and the surface of Fifth avenue to depress a roadway on 42nd street and also to relocate the subsurface structures. It would even be possible to raise the grade of Fifth avenue slightly if necessary. The plan (Figure 4) is to depress the surface tracks in the center of 42nd street immediately after clearing the Madison avenue crossing to permit cars to get underground in the shortest possible distance; and immediately after they have entered the portal to spread the tracks to provide room in the center of the street and also to depress a roadway to permit vehicles to cross under Fifth avenue. The method of depression on the west side will be similar to that on the east side. This arrangement will give independent depressed roadways for both the surface cars and vehicles. Directly under the intersection of Fifth avenue these passages will be side by side, the vehicular roadway being in the center and the surface car tracks on either side.

Underground sidewalks should be provided extending from the Grand Central station to some point west of Fifth avenue, so that pedestrians using the Grand Central station may use these sidewalks and avoid crossing Fifth avenue on the surface. There is now

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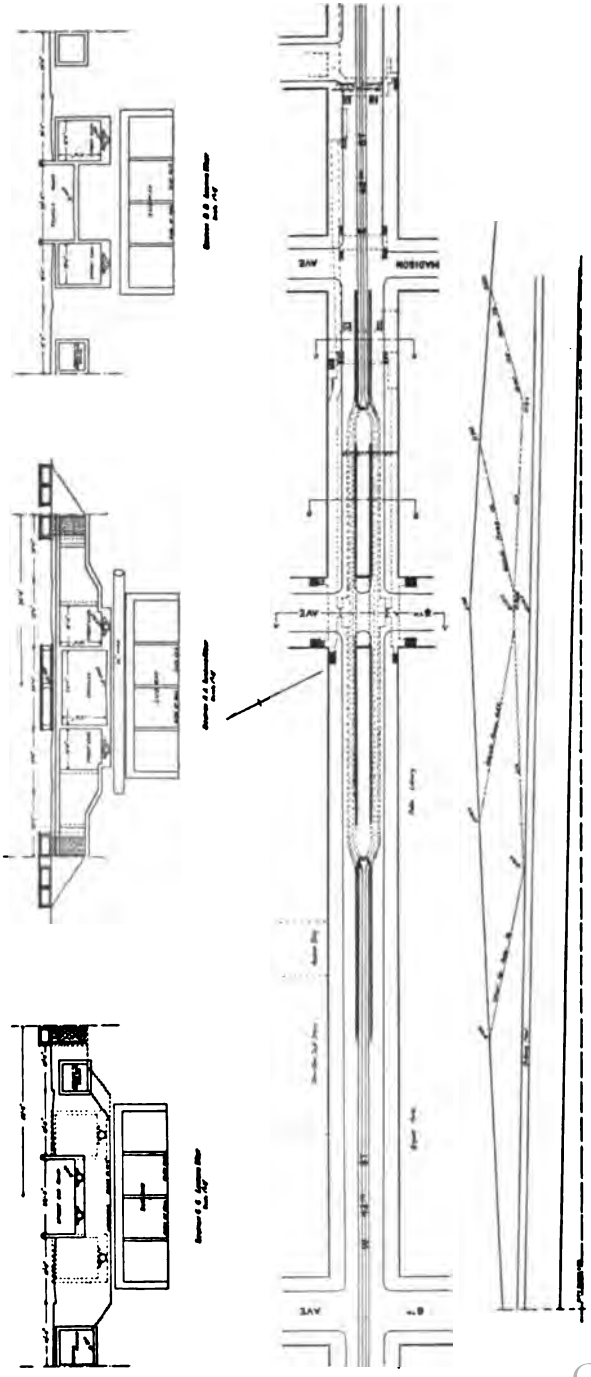

FIGURE 4—DEPRESSED ROADWAY IN 42ND STREET UNDER FIFTH AVENUE FOR STREET CARS AND VEHICLES.

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a mezzanine platform in the Grand Central subway station extending to the building on the northwest corner of Vanderbilt avenue. This platform can be extended over the local north-bound subway track to a point west of Madison avenue without interfering with the operation of trains. From this point it should be extended at least to some point west of Fifth avenue, next to the building line so as to permit show-window display. Eventually it should be extended to the subway station at Times square. I understand that the Transit Commission has in contemplation the construction of a moving platform on 42nd street. There should be no interference, however, between these two projects. The separation of the grades of Fifth avenue and 42nd street is, perhaps, fully as important as the moving platform and the latter can be constructed in the north-bound local track.

Depew Place

Negotiations have been pending between representatives of the City and the New York Central Railroad Company since the beginning of the year to open Depew place between 42nd and 45th streets to public traffic.

Immediately upon the opening of the Park avenue viaduct a point of congestion of traffic developed at 45th street and Vanderbilt avenue. Here traffic moves east and west on 45th street and north and south on both the upper and lower levels of Vanderbilt avenue. The untangling of the confusion taxes the police officers to the utmost. Making the upper level of Vanderbilt avenue and the Park avenue viaduct a south-bound, one-way thoroughfare in the morning and north-bound in the afternoon was first tried. At present traffic moves in both directions under police regulation. The gain in time made by an uninterrupted movement from 40th street to 45th street is often lost at 45th street on account of the congestion there.

Within six months after traffic started to use the viaduct, its intensity was greater than that on Fifth avenue. It soon became apparent that additional facilities were required to accommodate traffic in this part of the City.

The opening of Depew place around the easterly side of the Grand Central station suggested itself as the best means of relief.

The New York Central Railroad Company owns the fee title to Depew place and constructed a roadway for its own use to give access to the Commodore hotel and to the baggage room and the United States mail building. While the roadway already exists, it

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cannot be used for public traffic without interfering seriously with its present use. It is also undesirable for north and south bound traffic to cross 45th street at grade on account of the concentration of traffic on this street due to the fact that the Grand Central station closes 43rd and 44th streets between Vanderbilt and Lexington avenues.

In order to give the greatest measure of relief it is proposed to carry both the roadways of Depew place and Vanderbilt avenue over 45th street so as to separate north and south bound traffic from east and west bound traffic on 45th street (Figure 5). After crossing 45th street overhead these roadways will be located on private prop-

FIGURE 5—ELEVATED ROADWAY IN DEPEW PLACE AND VANDERBILT AVENUE.

erty on the north side of 45th street between Depew place and Vanderbilt avenue and in Park avenue meeting the existing grade at 46th street and Park avenue. In order to give still further relief it is proposed to confine the use of Park avenue between 45th and 46th streets to through vehicular traffic and to pedestrian traffic. To accommodate the traffic bound for the Grand Central station and for 43rd and 44th streets between Vanderbilt and Madison avenues it is proposed to open Vanderbilt avenue between 45th and 46th streets.

To carry out this improvement the City must acquire easements from the railroad company on the north side of 42nd street from the Park avenue viaduct to Depew place, on Depew place from

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42nd street to 45th street, on the north side of 45th street between Depew place and Vanderbilt avenue, and on Vanderbilt avenue from 45th street to 46th street. A roadway width of not less than 25 feet will be provided except for a short distance on Depew place where a width of only 20 feet can be obtained. To offset the cost of these easements it is proposed to sell to the railroad company the air rights on Park avenue between 45th and 46th streets remaining after the City has constructed the roadway and sidewalks. The City will also bear the cost of all roadway construction except that of Vanderbilt avenue from 45th street to 46th street which will be assumed by the company.

The company proposes to erect a building on the entire plot bounded by 45th street, 46th street, Vanderbilt avenue and Depew place, through which will run the inclined roadways and the sidewalks.

Vehicular Tunnel Traffic

The estimates of the Vehicular Tunnel Commission as to the maximum amount of traffic which the tunnels can accommodate is 13,270,000 vehicles per year, or 39,000 per day, or 3,200 per hour. The hourly estimate is on the basis of a 12-hour day. The estimate of traffic the first year after the opening of the tunnel is 16,500 vehicles daily, or about 1,400 per hour. The number of vehicles per day using Fifth avenue, between 42nd and 43rd streets, on April 16, 1920, was 19,080. The maximum density occurred between five and six o'clock and amounted to 2,321 vehicles. According to the estimates of the commission it will be but three years after the opening of the tunnel when the traffic will be equivalent to that on Fifth avenue. Fifth avenue has a roadway width of 55 feet and permits the movement of six lanes of traffic, three in each direction.

The Tunnel Commission contemplates the routing of north-bound traffic from the exit of the tunnel through Vestry and Laight streets to Hudson street and then north on Hudson street. It is pointed out that, while Hudson street is a 100-foot street, it contains two tracks of the New York Central Railroad freight line from the freight station at Hubert street to Canal street and above Canal street a two-track trolley line, both of which will interfere very materially with the free movement of vehicular traffic.

The Tunnel Commission contemplates adding 60 feet to the width of the roadway on the west side of Varick street, between Laight and Vestry streets, believing that this is sufficient to per-

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mit the traffic to disperse. It is contended that this widening of the roadway will not give sufficient space to permit the tunnel traffic to get away from the exit promptly. The routing of northbound traffic through Vestry, Laight and Hudson streets is not practicable on account of the narrow roadways of Laight and Ves-

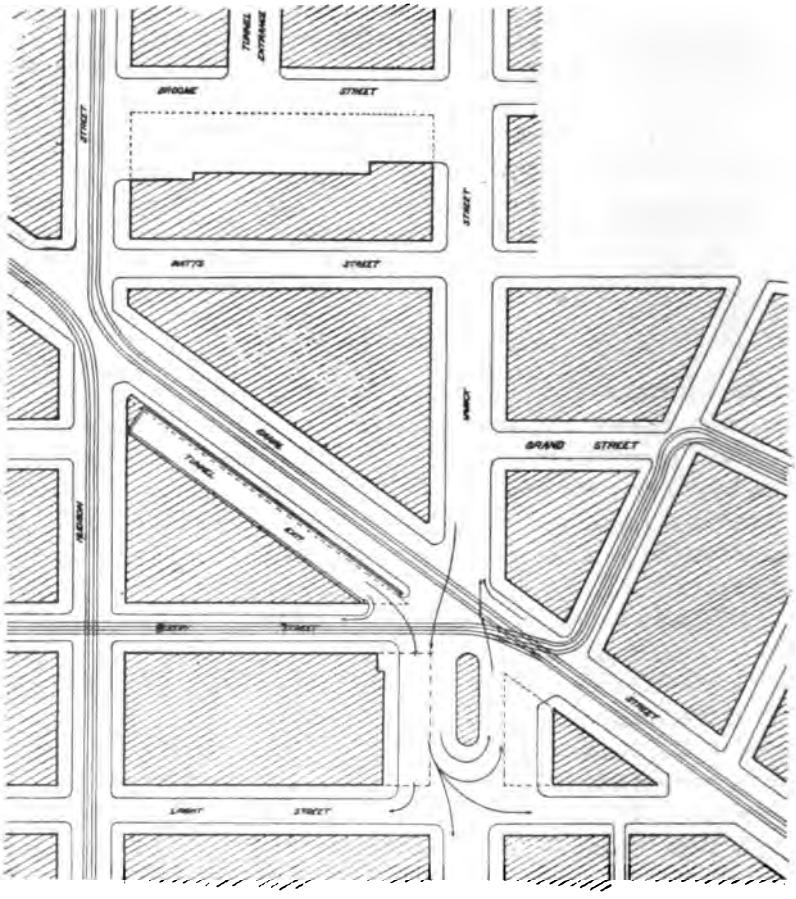

FIGURE 6—ROTARY MOVEMENT OF TRAFFIC AT VARICK AND CANAL STREETS.

try streets and the car tracks in Hudson street. Vestry street also has a two-track surface car line. In order to properly take care of this traffic at the exit of the tunnel, it is necessary also to widen Varick street on the easterly side, between Laight and Canal streets, so as to permit rotary movement of traffic similar to that at Columbus Circle (Figure 6). Instead of sending traffic from the

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erly end where it runs into Broadway. St. Nicholas avenue is the outlet to the north of all traffic on the northerly end of Washington heights. It has a grade which is so steep that it is dangerous for heavy traffic and undesirable for light traffic, so that for all practicable purposes Broadway and Riverside drive are the only outlets for Manhattan traffic to the north.

River street will form a new connection between Seventh avenue and the Harlem River speedway upon which a high-class pavement is now being laid. This will give an outlet for traffic through Cen-

FIGURE 7—WATER-LEVEL STREET CONNECTING SEVENTH AVENUE WITH HARLEM RIVER SPEEDWAY. RIVER STREET.

tral park, Fifth avenue and the other avenues on the east side of Manhattan to the Dyckman valley without climbing the Washington Heights hill or crossing into The Bronx and back again.

RIVERSIDE DRIVE EXTENSION

Riverside drive is another incomplete improvement north of 155th street. The intersection of 158th street, Audubon place and Riverside drive is dangerous both on account of alignment and grades. North of 158th street it has never been graded and improved to its

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is congestion at times which is bound to increase. Broadway, as already stated, is the only other thoroughfare over Washington Heights, and Dyckman street is the artery leading to the ferry to New Jersey and the Interstate park. Riverside drive should be carried to the City line independent of any other important thoroughfare. The extension of the drive should begin at or near the summit in the present drive south of Dyckman street and should be located along the westerly ridge of the hill at an elevation to cross overhead of the present drive leading down to Broadway and Dyckman street. This would separate the traffic bound to Yonkers and up the Hudson from that bound for the Dyckman Street ferry and New England. It would ease up traffic conditions very much at Dyckman street and Broadway. (Figure 8 gives some concep-

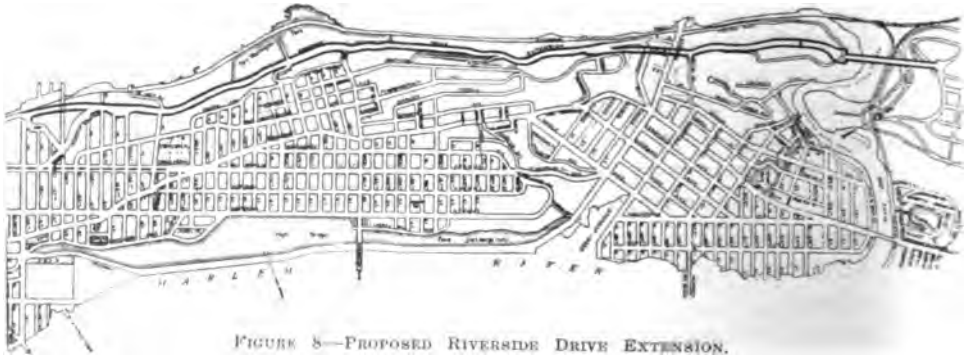

FIGURE 8—PROPOSED RIVERSIDE DRIVE EXTENSION.

tion of the proposed plan but it is not intended to show a definite location or plan.)

MARGINAL AVENUES

A north and south bound traffic count taken a little over a year ago shows that traffic decreases from the center of the island toward both shores and that the avenues near the rivers have relatively little traffic. A glance at the map of Manhattan (Figure 9) convinces one that traffic from the lower part of the City bound for The Bronx, New England and Westchester county would find the avenues along the edge of Manhattan at least as direct as Fifth avenue or Park avenue and they are very much less congested. The map also shows very clearly the abrupt termination of the east side avenues at Houston street and most of those on the west side at various points not far from 14th street. Immediate steps should

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be taken to extend these avenues to the lower part of the City, so as to make them easily accessible to traffic from this vicinity. The extension for the east side avenues should be made so as not to interfere needlessly with the traffic on the East River bridges. This can be done by locating them far enough to the east to pass under the bridge approaches. On the west side, similarly, extensions must be so laid out as not to conflict unnecessarily with the vehicular tunnel traffic.

FIGURE 9—AERIAL VIEW OF THE BOROUGH OF MANHATTAN.

EFFECT OF PAVEMENTS ON TRAFFIC

Any effort to direct traffic through new routes must include not only good alignment and easy grades, but suitable pavements. Traffic will not use poor pavements. This is very clearly indicated on the diagram (Figure 10) showing traffic on Centre street and on Fourth avenue, each of which has car tracks. Centre street had a rough granite block pavement while that on Fourth avenue was a high-grade granite block pavement when the traffic observations

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were made. In each case the hatching from right to left shows the vehicular traffic and that from left to right the surface car traffic.

It will be observed that on Centre street the vehicular traffic using the car tracks is a little larger than that using an equivalent

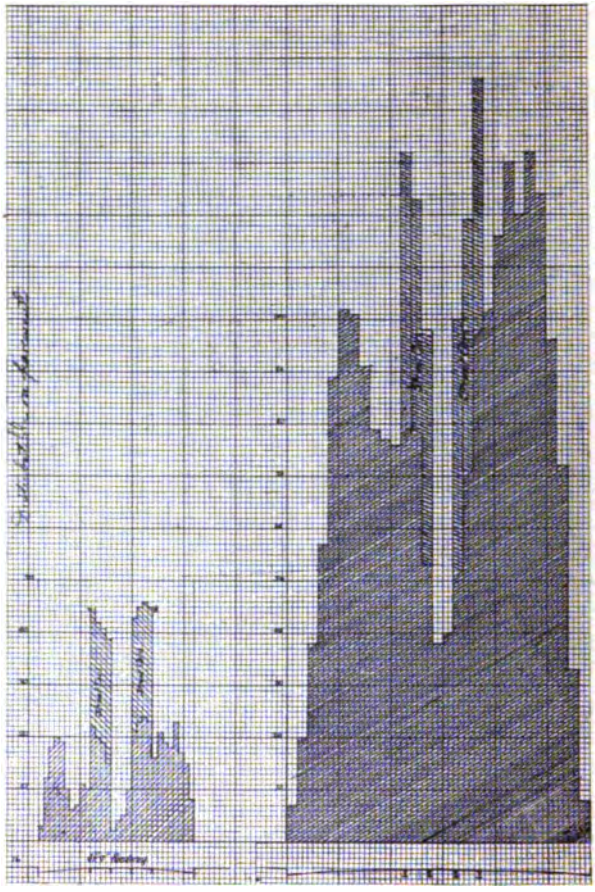

FIGURE 10—EFFECT OF PAVEMENT ON TRAFFIC. THE DIAGRAM ON THE RIGHT IS FOR FOURTH AVENUE.

width of roadway outside of the tracks, whereas on Fourth avenue, which had a good pavement, the volume of traffic for a similar width of roadway is very much greater outside of the tracks than on the tracks. In other words, where the pavement is bad, vehicles will seek the car tracks, and where it is good they will avoid them. As

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four tracks. There is little doubt that eventually six or more would be required. A structure of the width to accommodate six or more tracks would take away so much light that the street would become very undesirable as a public highway. Should it be desired to lay tracks on the piers, a very heavy structure would be required which would put an additional unnecessarily heavy load on them.

The logical arrangement would seem to be to locate the tracks on the surface of the street and put the roadway on an elevated structure (Figure 11). This arrangement would make the construction of the railroad comparatively inexpensive since it could be built on the present surface of the street. The construction of tracks to piers or to private property would be likewise inexpensive. The elevated structure to carry vehicular traffic would be light and inexpensive compared with an elevated railroad structure. The operation of the railroad would be hidden from view. It would be possible to assess the change of grade damages on private property for benefit, if benefit could be shown, whereas damages paid for loss of light, air and access on account of an elevated railroad structure can never be recovered. An elevated highway along the west water-front would, no doubt, offer much relief to congestion of traffic in the central part of the island. Such a structure should not be considered by itself but in connection with the solution of the railroad problem on the west side.

The foregoing is submitted not as an enumeration of all the specific things to be done, but rather as an illustration of the kind of improvements which should be made to existing facilities. The time will no doubt come when additional thoroughfares will be required, but that time can be postponed indefinitely if the existing facilities are conserved and enlarged in capacity as the needs of traffic demand.

Discussion

CHARLES U. POWELL,* M.M.E.N.Y.—I was impressed with the author's statement about the traffic in Park avenue over the 42nd street viaduct, where that narrow roadway so easily takes the traffic of the much wider Park avenue. It shows that where traffic can freely flow, even a narrow street can carry a great volume.

I am very much interested in the possibility on wide thoroughfares of assisting in maintaining a freedom of traffic flow by striping or

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marking the roadway into lanes. I would like to know if anyone has any information in regard to this. I believe that it is a field for study which might result in greatly increasing the carrying capacity of some of our wider streets. The relative speed in these lanes could be regulated so that the slower vehicles would not retard the more speedy.

I know of one example where such classification has been very effective—on Broadway, which leads out through the north side of Long Island. On a Sunday, vehicles are almost within five or ten feet of one another in a continuous stream going east, probably traveling only 12 or 15 miles an hour. When they reach the Douglaston hill, which hill has a grade of about seven per cent. and continues for about 700 or 800 feet, the roadway widens out slightly so that the vehicles are permitted to pass one another, and because of the grade the higher-powered cars are able to pass the more slowly-going vehicles. This little space of 700 or 800 feet acts as an automatic sorting yard, where fast cars go ahead and the slow cars stay in their places. As soon as you pass the hill, although no side streets absorb the traffic, one is agreeably surprised to find that there are few cars in the immediate vicinity. The reason is that they have been automatically sorted in that space; the first cars have gone ahead at, say, 25 miles an hour, if not faster, and the slow cars at 15 miles an hour stay behind, and the traffic congestion has disappeared.

Studies along that line, I think, might be important, especially in our suburban districts.

I would like to know if there are any representatives here from civic organizations, boards of trade, etc., who can add to this discussion. If so, I would be glad to hear from them. The other boroughs have practical problems that would add to this discussion. Mr. Farley is here and we would be glad to hear from him.

PHILIP P. FARLEY,* M.M.E.N.Y.—Naturally, I have not had time to reflect very deeply on what the author has said. Nevertheless, I was extremely interested in many matters to which he has made reference. Some of these matters refer to improvements which the Borough of Brooklyn has undertaken during the past two or three years.

The first thing of interest to me was the removal of encroachments and the effect of the removal of these encroachments on the

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property-owners. When proposals are first made to remove building encroachments from streets, the owners are very apt to protest, and protest vigorously. A year or so ago an order was issued by the Borough President of Brooklyn for the removal of encroachments on Manhattan avenue between Driggs and Greenpoint avenues. This is a very narrow street in the Greenpoint section of the borough and before the removal of the encroachments was very much congested. In the evenings, particularly, it was almost impossible for pedestrian traffic to move freely. When the order was first issued a very large number of protests were received in the Borough President's office, but, notwithstanding these, the Borough President was insistent that the encroachments be removed and the plan was carried out. Since completion it is amazing to hear remarks and comments that come from the Greenpoint section as a result of the changes that have been made, and these comments are made not only by citizens in general, but by the property-owners themselves, notwithstanding the fact that they were put to considerable expense. The street now has an entirely different appearance. In many cases the store fronts have been remodeled and reconstructed, so that, from a crowded, dingy-looking street, Manhattan avenue has now taken on the appearance of an up-to-date business thoroughfare.

I was also interested in the author's remarks about the effect on the diversion of traffic by the improvement of parallel streets. Two years ago we had occasion in Brooklyn to pave Atlantic Avenue, on which for many years a steam railroad operated along the middle portion. When the Long Island railroad was placed in a subway a dirt strip remained where the right-of-way formerly existed. For well over ten years this dirt strip remained unimproved. In 1920 it was paved and after paving, for a month or six weeks, very little traffic took advantage of it. Although the improvement had frequently been mentioned in the public press, automobile owners and operators did not seem to be aware of it, or did not realize its importance. Then a change took place which was almost startling. In the course of eighteen months the traffic on Atlantic avenue has increased to such an extent as to reach at times the point of congestion, but with a consequent relief to other thoroughfares which had before that time been obliged to take the bulk of traffic.

If similar treatment were given in Manhattan I am quite certain that great relief would be afforded to streets which are now congested. It appears to me that very great advantages would follow

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selected as routes. Many of the most prominent streets in this City are defaced in this manner. Particular examples of this are found in Flatbush avenue from Fulton street to Atlantic Avenue depot, on Fulton street from Brooklyn bridge through the main shopping territory, both in the Borough of Brooklyn, and on the Bowery in the Borough of Manhattan. These elevated lines are old structures and perhaps there may be some excuse for their presence in these roadways, inasmuch as the designers could not foresee the development of the City, but the same cannot be said of the treatment of the structures in the vicinity of the Queensboro Bridge plaza, the beauty of which has been positively destroyed during the past ten or twelve years. It would seem that in the design of structures one principle should be kept in mind, and that is that the surface of streets is intended for vehicular and pedestrian traffic, and should in no case be given over to other uses.

The Borough of Brooklyn for several years past has been endeavoring to have removed four or five elevated railroad columns across Atlantic avenue in the vicinity of Fifth avenue, at the very entrance to one of the best thoroughfares in the borough. Up to the present time no success has attended the efforts to have these obstacles removed. The time to have prevented the construction of such columns was when the plans were being prepared. It seems to me that all plans and designs of structures of this kind should be sent to the Board of Estimate and Apportionment for approval, and should be referred by that board to the Committee on City Plan.

DANIEL L. TURNER,* M.M.E.N.Y.—I think the author has given us a very far-seeing view of some of the methods that must be used in dealing with the traffic problems in New York City. There is no doubt in my mind that one of the most important things to be done in New York is to extend and modify the Zoning Law, so as to exercise a greater control over private activities throughout the City, and not only the character of the activities, but also—a point that the author did not touch on—restrict to a greater extent the height of buildings that can be constructed under the building Zoning Laws. The photograph that was shown on the screen, dealing with Manhattan, which showed the grouping of the high buildings just below the park and in the lower part of Manhattan emphasized

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the situation. When one considers the potential possibilities in New York City, under the present Zoning Laws, of expanding that high building development, it is utterly impossible to conceive of any adequate way of dealing with the transportation problem. I mean the transit problem, leaving out the question of the vehicular traffic in the streets, which is another difficult problem. Do you realize that an ordinary twelve-story apartment building produces a density of population equivalent to the densest population in the world, that in the lower east side? From this you get an idea of the potential possibilities from a population standpoint of the ability to continue the development of that class of building.

We cannot compete with that kind of housing development in producing transit. We cannot compete with the kind of development that permits a forty-story office building to go up with a working population of 13,000 or more, consuming one-third of the capacity of a subway. One building occupying one block will thus absorb a third of the capacity of a new subway. I have been thinking about the problem a good deal along the lines that the author has followed, with the same object in view of having the City exercise a more drastic control over the development of the areas within the City limits. The purpose of our transit plans, of course, is to diffuse the population, to decentralize the population and the activities of the City. Now, in order to be able to do that, two things must be done—we must control the use of the land for building purposes and we must provide the necessary transit facilities to diffuse the population. Having provided ways and means for the people to spread themselves out over the whole City, we must then clamp down the lid so that the City cannot grow up into the air. If we are going to go on and permit unlimited building, we cannot begin to cope with the transit problem. The saving feature in the past has been that the intensive development has only taken place in small areas such as that photograph very clearly indicates.

I think what the author said about the 34th Street situation is interesting too. It is an improvement that ought to be effected at Broadway and 34th street. I can see more possibilities for mutual co-operation between the Transit Commission and the City, and that is what we need—co-operation. These problems can only be dealt with adequately through co-operation.

There was one other thing, and that is in reference to the author's remarks about utilizing the streets to a greater extent than now

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utilized. I believe with him that there is a great deal of capacity undeveloped in the streets, and the fact that it has not been developed and is not being utilized is largely due to the license that is permitted in the parking of vehicles along the roadways. I think there is nothing needed so much in this City, from a traffic-regulation standpoint, as the compelling of automobiles not being used to be parked off the streets, in garages, buildings, or in open spaces, at any rate off the longitudinal streets; also a vehicle ought not to be permitted to stand tail-end to the curb. Go up any of the longitudinal avenues we have and you find whole blocks restricted to two lines of traffic, simply because vehicles are standing with the end to the curb. What we need is the kind of regulation that will prohibit such conditions. We need it in the case of car movement. If we could clear the streets of standing vehicles, keep the vehicular traffic moving and keep it off the car tracks, we could accelerate the speed of the surface cars from six or seven miles an hour up to 12 miles an hour, and induce a better use of these facilities.

The author has hit the keynote of the situation—the City must have and exercise better control.

A MEMBER.—I would like to ask, in reference to the subways, could the stations be lengthened and the number of cars doubled to twenty instead of ten?

MR. TURNER.—There are some possibilities in lengthening the trains but it is a difficult problem and not so easy as it might seem. When we opened the subway we were operating eight-car trains, and it seemed at first a simple thing to change from eight-car operation to ten-car operation, but it represented, as I remember, an immediate expenditure of something like $7,000,000 in rebuilding the entire equipment of the Interborough line, to permit two cars to be added to the train. All the draw bars and brake equipment had to be scrapped; it had not been in operation more than a few years and it was a very difficult thing to get the talent in this country to devise the new draw-bar and brake equipment to permit the operation of these new trains, primarily because of the length of the train and the difficulty of controlling the release of the brakes from one to the other. It required a new type of brake before it could be done. They actually pulled trains apart in the effort to operate ten-car trains with the old equipment. Whether we can increase the number of

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cars beyond ten I do not know. I am not qualified to say. The difficulties that would be involved might be just as great again. We might have to go over the whole equipment of the cars and revamp them to meet that additional burden,—additional stress on the train connections.

We have not considered very much the idea of increasing train lengths above the maximum we now have of ten cars. I was speaking of the equipment. Suggestions have been made of continuous train operation, and it was carefully analyzed and considered at the time, but I doubt the advisability of it. Of course, another thing, too, is the difficulty in controlling traffic, apart from the cost of lengthening the stations which, of course, would be very large. We cannot diffuse the traffic through the streets. It will concentrate. Take Times Square station for example. It is not only at the street-traffic limit but at the transit-traffic limit. Despite anything we can do, we cannot compel people to utilize the station at Times square equally throughout its length. Everybody wants to go in at 42nd street, although the station overlaps 41st and 40th streets. These are the difficulties with long stations, particularly at congested points. I doubt the advantage of running trains any longer than we are now operating them.

HARRY N. LATEY.*—One word in regard to the twenty-car-train proposition. There is one very serious thing that develops as soon as you start to handle long trains. In operating a ten-car train, provision must be made to push a ten-car cripple back to the shops, which means the operation, under your present system, of a twenty-car train. If you were running twenty-car trains under normal conditions, you would have to operate a forty-car train back to the shop in emergency. There is undoubtedly some increase in the capacity, due to the use of the additional cars, but it is not two to one. The block-signal system would have to be radically increased on account of the larger train. I do not know how much the increase would be but it would not be in proportion to the increase in the number of cars.

One thing I would like to ask the author, and that is about the objections to the five lines of traffic in narrow streets. It seems to me that there are two cases, one case particularly, where this would be of great advantage and that is where you have a single car tran-

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sit line in the middle of the street; take 28th street—a trolley car in the middle and a line of automobiles against the curb. The only way to get through is to wait until the car gets out of the street, and it seems to me that if we are going to have trolley cars in the center of the street, it might be very desirable to have a fifth line on these streets. Also, on single-direction streets, it seems to me that it would be desirable to give one more line of traffic.

AMOS SCHAEFFER (the Author).—The 28th and 29th street trolley lines have discontinued operation, and I think everybody would like to see the tracks taken up; the City would, I am sure. I meant to say something about the tracks in our streets. Suggestions have been made, both from the Transit Commission and other sources, that the surface car operation should be materially reduced, and I think it would help the traffic situation materially. I believe that the operation of motor buses is more elastic and would permit a greater amount of traffic of all kinds in many streets than the surface car operation. In the case of a single trolley track and two lines of vehicular traffic moving in opposite directions, I think, as far as the track is concerned, there would be no objection.

The other thing I failed to mention is that a certain ratio must be maintained between the width of the roadway and the width of the sidewalk. For example, take a 60-foot street and put in five lines of traffic. That would require 45 feet of the 60 and would leave only 15 feet for two sidewalks—that would not be sufficient to meet the demands of the pedestrian traffic; so there is a limit to the amount of reduction that you can apply to the sidewalk. I think there would be no objection to an odd number of lanes of moving vehicles in one direction, but that is traffic regulation. It undoubtedly has worked well so far but I doubt if the City would be warranted in making a large expenditure for traffic on the basis of traffic regulation, when tomorrow it may change. Perhaps the best reason why we should not have more than four lines of traffic on a 60-foot street is that you do not have room to put in an additional line, for you would rob the sidewalk of too much space.

HENRY W. VOGEL,* M.M.E.N.Y.—The author's suggestions for alleviating traffic congestion by making the most of our present facilities gave me great pleasure.

* Past President of the Society; Surveyor, Department of Taxes and Assessments, New York City.

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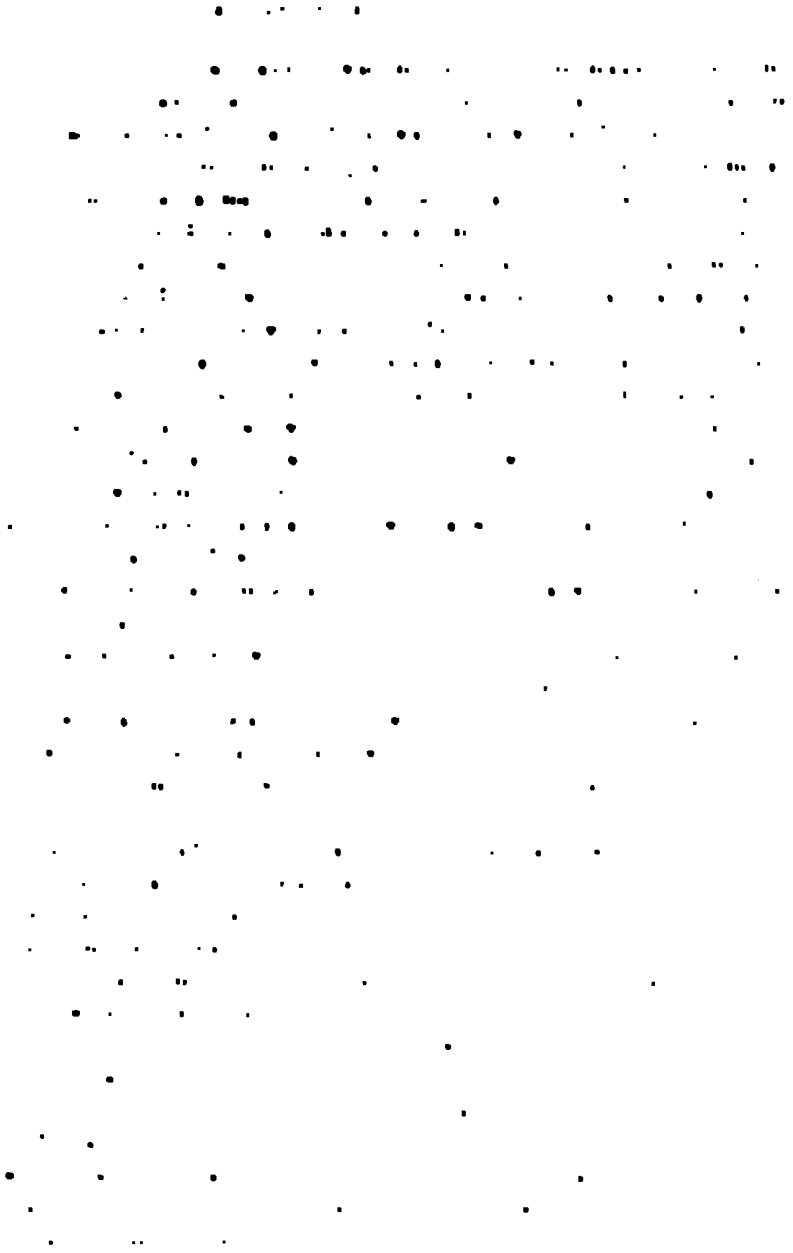

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Paper 133

Presented December 27, 1922

JAMAICA BAY—A MODERN SEAPORT

By T. F. Keller,* M.M.E.N.Y.

With Discussion by Henry A. Meyer, Philip P. Farley, Henry R. Asserson, Charles U. Powell, J. W. F. Bennett, Francis T. O'Keefe and the Author

It is an accepted fact that in the layout of a modern water-front terminal the site selected must contain certain fundamental essentials either existing or economically potential. No terminal is as profitable as the route of transportation and if the terminal and its costs could be eliminated the question of transportation rates would be a matter of plain arithmetic. The terminal, however, is a necessary evil, and no route of transportation can be considered as desirable unless its terminal is made as near perfect as possible. Terminal handling reduced to a minimum of cost will determine to a large extent the profits from any transportation business.

The spirit of competition existing to-day, with the awakened interest from the natural growth in the volume of trade, and from the lessons learned in the Great War, will demand the development of terminals planned and equipped to the maximum of efficiency and economy. The efficient route of transportation must be determined by the efficiency of its terminals.

The fundamental physical essentials of a modern seaport terminal are water facilities, rail facilities, pier facilities and highways. It is my object in presenting this paper to examine the Jamaica Bay project with these essentials in mind and to endeavor to point out good and sufficient reasons why the project, carried along and kept alive for so many years by the visions of the few, and now advanced to such a stage that indicates active progression in the future, answers all of these requisites.

A word first of the history of the project.

Jamaica bay has an area of 26 square miles, and is located in the southeasterly corner of the Greater City. It is thoroughly pro-

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located and well sheltered, and is connected with the Atlantic ocean by Rockaway inlet, a body of water 3,000 feet wide, separating Barren island and Rockaway beach. Most of the seaports of the United States are many miles distant from the open sea, and in their development many natural obstacles in the creation of deep-water channels and in their maintenance must be overcome. Recently there was opened a magnificent municipal terminal at Portland, Maine, and one of the advertised features of the pier was the fact that the open sea was only three and one-half miles distant. I take pride in pointing out that, although the Port of New York has always been looked upon as one of the few great ports located on the sea, the City of New York now has the opportunity of building a tremendous steamship terminal within three miles of the open sea.

In 1906, Mayor George B. McClellan appointed the Jamaica Bay Commission to investigate the general improvement and development of Jamaica bay in the Boroughs of Brooklyn and Queens. This commission reported to the Board of Estimate and Apportionment and automatically went out of office May 31, 1907.

On March 2, 1907, Congress directed the Secretary of War to make a survey of the bay and to co-operate with the City of New York. The Jamaica Bay Commission was re-appointed by Mayor McClellan on June 7, 1907, and in addition to its original duties they were directed to confer with the Secretary of War, relative to the survey and examination of Jamaica bay, and to recommend plans for the improvement thereof. In its report dated December 27, 1909, the Jamaica Bay Commission made the following recommendations: "That the growth of the Port of New York warrants and justifies a substantial improvement of Jamaica bay".

Colonel John G. D. Knight, the United States District Engineer, under date of January 30, 1909, approved the Jamaica Bay project and recommended Federal co-operation. On May 29, 1909, the State of New York ceded to the City of New York its title to Jamaica Bay lands under water by the enactment of the Sargent Bill. The purpose of this cession was that the City of New York may co-operate with the Federal government in the creation of a new harbor in and about Jamaica bay, intended for the advancement of the commercial interests of the City, State and Nation. On June 25, 1910, by House Document 1488, the 60th Congress, 2nd Session, approved the Jamaica Bay project and made an initial appropriation.

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The co-operative agreement provided that the construction and maintenance of an entrance channel should be done at the expense of the Federal government, the channel to be 18 feet deep and 500 feet wide at first, and to be deepened and widened to 30 feet by 1,500 feet when the requirements of commerce would demand it. The agreement further provided that the City of New York would dredge the main interior channel from Barren island to the mouth of Cornell basin, a distance of eight miles at first 18 feet by 500 feet and eventually 30 feet by 1,000 feet. For this main channel dredging the Federal government would reimburse its agent, the City, at the actual unit price per cubic yard, place measurement, up to 8 cents per yard. The City under the agreement would build the necessary basins, wharves, etc., to justify the creation of the channels. So in 1910 the Jamaica Bay project was inaugurated auspiciously.

The City of New York had indicated for partial improvement only, an expenditure of $69,270,000 and had appropriated $950,000. The Federal government had indicated as its cost $7,430,050 and had appropriated $250,500. The State had ceded 16,000 acres of lands under water. The City was in a position to remedy the apparent faults of its water-front occasioned by the fact that the City grew too fast, so that adequate provision for water-borne commerce could be made, and the diversion of trade to competing ports would be stopped.

New York's wonderful harbor and water-front have made New York great. A great many admire our Fifth avenue and believe that our wonderful avenues and stores have made us big, but the true reason is the busy water-front. A lull in shipping is reflected through all avenues to the very heart of the City. New York, the easiest port in the world to get commerce into, was becoming the most expensive port to get commerce through.

It has been stated that in 1899 the number of wage-earners in the Greater City was 388,000 with value of products of $1,173,000,000. In 1909, a growth of 10 years, the number of wage-earners increased to 554,000 with value of products of $2,029,700,000. In 1919, a growth of 20 years, the number of wage earners was 639,000 with a value of products of $5,260,700,000. The latter figure is undoubtedly high, due to the high costs of 1919. It may be necessary for purposes of comparison to reduce this amount to $3,000,000,000. This comparison shows an increase in the number of

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wage-earners of 65 per cent. and in the value of products of 150 per cent. in the twenty-year period.

In 1900 the total foreign imports and exports at New York, exclusive of specie and bullion, amounted to $1,196,000,000. In 1910 they amounted to $1,746,000,000 and in 1921, a year of depression after a peak amount in 1920 of $6,644,000,000, they amounted to $3,697,000,000. The increase from 1900 to 1921 has been 210 per cent.

These two comparisons are presented with a view of showing the growth of the City's industries, and of its foreign trade. Jamaica bay from its first study and investigation has always been looked upon as an ideal location where industries could be served by rail and water transportation, and, with the growth of the rapid-transit system in the past decade and more wonderful growth in the future, the shore line of the bay and the borders of the commodious tributary basins will be in close proximity with the great labor supply of Brooklyn and Queens.

Examine the map of Brooklyn. Note the fact that the thickly-populated district of Brownsville is within a short distance of the head of Fresh Creek basin as laid out. In population New York City is the greatest city in the world. It is foremost as a commercial center and as an industrial center. With the natural and progressive expansion of the City, where can the City find the necessary location? The answer is Jamaica bay. This is the only waterfront that can be developed with the vision that future generations will require.

The project in 1910 seemed to have been launched under favorable auspices. The City in 1913 dredged an interior channel 18 feet deep and 500 feet wide extending 8,800 feet in a northerly direction along the west side of the bay, from Barren island to the entrance to Mill basin. The price for this was $0.0765 per cubic yard, for which the Government paid the entire sum, as it was less than the 8 cents unit cost agreed upon for reimbursement. In 1915 and 1916 it built a bulkhead platform 400 feet in length at the head of Mill basin near the foot of Flatbush avenue. The Government provided an entrance channel to the bay 20 feet in depth. This work, trivial in comparison with the undeveloped acreage of Jamaica bay, has resulted in a great commercial activity on the privately-owned land around the head of Mill basin.

In 1917, changes in the lines between Mill basin and Fresh Creek basin were proposed by the Dock Commissioner, and after a public

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hearing thereon, were approved by the Secretary of War. The change consisted in shifting the pier-head and bulkhead line as laid down by the Secretary of War in 1911, a distance inshore about 1,000 feet. The channel lines, along which it was expected that the City would dredge, and for which it would be reimbursed by the Federal government at the rate of 8 cents per cubic yard, were left unchanged. The channel lines were left suspended in the bay, so to speak, with an intervening distance to the pier-head line of almost 1,000 feet. The City had learned its costly lesson of providing for steamship piers in the Chelsea section by cutting into the back land, necessitating costly dredging and the acquisition of valuable improved upland. Jamaica bay, unimproved, presented the ideal location where for all time a modern development, commercial and industrial, could be built, and instead of making more water it was necessary to squeeze out the water and create upland. The disagreement of the harbor lines and the channel lines gave rise to a condition, making it impossible for the City to proceed with wisdom. The development seemed to be at a standstill.

In 1919, interest in the scheme was revived by an offer of a western capitalist to build bulkheads, wharves, piers, warehouses, etc., at his own expense under an agreement whereby the City was to lease the 800 acres of land between Barren island and Mill basin for a term of years, after which the City would obtain possession of the improvement. Certain conditions, however, were imposed, among them the access by land through the extension of Flatbush avenue into the mainland of Brooklyn and the creation of a 30-foot channel from the open sea to Mill basin.

The City, through the active leadership of the Hon. Murray Hulbert, then Commissioner of Docks, and now President of the Board of Aldermen, directed its energies to the fulfillment of these two conditions, realizing whether done by private or public funds that the improvement could not be carried on without these two obstacles removed. Federal help was necessary. To show the awakened interest of the City, the Sinking Fund Commission in November, 1919, set aside $7,500,000 for the construction of six piers between Barren island and Mill basin. This appropriation was made contingent on the action of Congress at its session beginning the first Monday in December, 1919, in authorizing the construction and maintenance of a 30-foot entrance channel 1,500 feet wide through Rockaway inlet to Jamaica bay and a 30-foot interior channel 1,000 feet wide up to Mill basin. The District Engineer,

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Colonel Edward Burr, a man of vision and a firm believer in the logical and necessary growth of the City's water-front by the development of Jamaica bay, made a favorable recommendation. Nothing, however, was accomplished except that the Jamaica Bay enthusiasts were delighted to see that the City acted as if it really intended to do something.

In 1921 some very definite steps were taken, which served to indicate to the Government that the City was really in earnest. In order to impress the Government that its demand for a 30-foot channel was actuated by a keen desire to develop Jamaica bay, the Dock Department asked for and obtained $750,000 for the construction of a reinforced-concrete pile bulkhead platform, from the end of the wooden platform built in 1915, a distance southerly and along the easterly side of Flatbush avenue of 2,200 feet, making the entire wharfage length now available with 18 feet of water alongside of 2,600 feet. The contract also provided for the straightening out of the winding channel leading from the main channel of Jamaica bay to Mill basin. The extension of Flatbush avenue has been held to be the gateway to Jamaica bay. The construction of the bulkhead now will enable the Borough President to carry on the work of making Flatbush avenue. Active steps are now being taken by him to this end, and it is to be hoped that within two years it will be possible to travel by automobile to the very end of Barren island.

A glance at the map will show that Flatbush avenue is a direct artery of traffic from Barren island to Canal street, North river, and the importance of extending it is at once apparent. By the construction of the bulkhead the City has furnished valuable facilities for wharfage in a fast-growing section, at a point only two miles from the geographical center of Brooklyn, and incidentally is now in a position to comply with another important condition necessary and precedent to the development of a monster terminal north of Barren island. The extension, furthermore, will provide a very direct and quick route, with a minimum expenditure of money, from Manhattan and Brooklyn into the Rockaways, and will put to use the little used Jacob Riis park at Rockaway beach. The new highway will bring into close communication the Navy Yard and Fort Tilden at Rockaway.

In 1921 the question of an understanding between the City and the Federal government was still in abeyance. The City had requested the restoration of the pier-head and bulkhead lines to the lines as established in 1911. On October 7, 1921, after a conference

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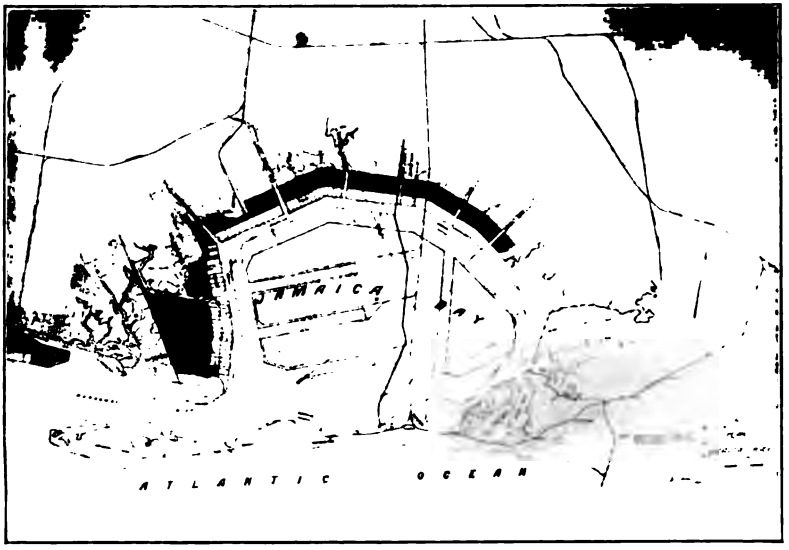
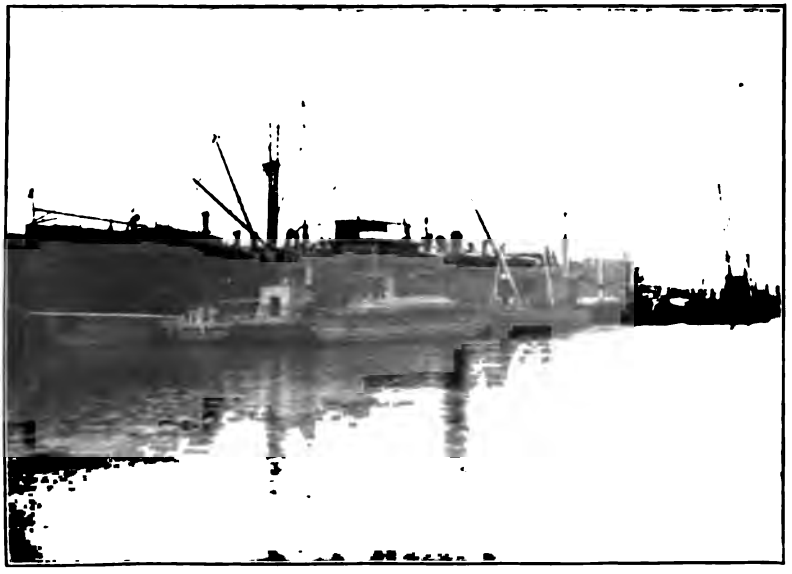


THE PROPOSED PLAN FOR THE JAMAICA BAY IMPROVEMENT, SHOWING (THE BLACK AREA) THE PROPOSED DEVELOPMENT OF THE MAINLAND AS A MARGINAL STREET AREA.



HANDLING FREIGHT OVERSIDE TO LIGHTERS. AT THE JAMAICA BAY IMPROVEMENT THE CARS CAN COME ALONGSIDE ON THE DOCKS.

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between the District Engineer, the Dock Commissioner and the Comptroller, the Commissioners of the Sinking Fund passed a resolution to the effect that "if the War Department will approve the restoration of the pier-head and bulkhead lines in Jamaica bay to the lines of 1911, the Commissioners of the Sinking Fund, within 90 days thereafter, will adopt a plan for the improvement of the water-front between Barren island in the Borough of Brooklyn and the Long Island Railroad crossing of Jamaica bay in the Borough of Queens; within the same period the Commissioners of the Sinking Fund will authorize the institution of proceedings to acquire all of the privately-owned land and land under water between Barren island and the Cross Bay boulevard, or the Long Island Railroad bridge, necessary for the development of this water-front in accordance with the plan submitted by the Dock Commissioner and approved by the Commissioners of the Sinking Fund."

Acting on this specific promise of performance, the Secretary of War on December 22, 1921, re-established the lines from Mill basin to Fresh Creek basin along the original 1911 lines. On January 5, 1922, the Sinking Fund Commissioners approved the plan for the improvement of the water-front as submitted by the Dock Commissioner.

On January 1, 1922, a new Dock Commissioner, John H. Delaney, was appointed. Essentially a business man, he has studied the Jamaica Bay project, and has during his twelve months in office advanced the project very materially, having been impressed with its vast possibilities. Initiated by him, condemnation of privately-owned land as far as Paerdegat basin has been authorized and the necessary steps are being taken at present to acquire the remaining land privately owned between Paerdegat basin and the Long Island Railroad crossing in Queens borough. This will place the City in absolute control of more than 6 miles of straight water-front from Barren island to the Long Island Railroad crossing of Jamaica bay, a stretch of unbroken City-owned water-front, all susceptible of modern development. I do not think that a similar water-front, municipally owned, exists elsewhere in the entire United States.

The area of this mainland development will be about 2,650 acres, of which the City had owned about 2,300 acres and acquired about 350 acres. This area for water-front development is one-fifth of the area of the entire Borough of Manhattan.

On September 22, 1922, the President of the United States signed the River and Harbor Bill of 1922, which contained the following provision:

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... nal to the entrance channel. There is a continuous movement of sand along the ocean side of Rockaway. The construction of the east jetty at the entrance of the government project of 1902 on the west side and the western limit of Rockaways ... on the ocean side and with the scouring action of the ... the ... relieve the maintenance of the entrance channel ... a comparatively easy matter.

... passing through the inner channel and widened at Government expense to 50 feet ... 1,500 feet to come within the limits ... the bar. The project as adopted calls for a channel 30 feet deep and 1,000 feet wide. The plan of the City, however, contemplates the development and reclamation of the interior islands of the bay and the channel of the future will be 2,500 feet wide around the entire sweep of the shore front with 30 feet of water, widening ... in front of Rockaway park. Belle harbor and Neponset to a magnificent roadstead for ships with a length of about 2½ miles and a ... of about 1½ miles at its maximum. The roadstead will accommodate safe anchorages for at least 150 ships. Two years ago ... Shooting Board anchored at this very location 112 ships.

The bed of Jamaica bay is composed of fine sand, topped with ... about 3 to 5 feet of marsh mud. An ideal bottom is presented for dredging hydraulically at a low cost, with the desirable benefit of ... converting the dredged material into useful land. In addition, there ... no danger of injury to vessels by fouling on hidden rocks.

For connection with the rest of the waterways around the port, the ultimate development contemplates the construction of an inland waterway or ship canal to provide a safer passage for barges, lighters and other small craft between Gravesend bay and Jamaica bay, and between Flushing bay and Jamaica bay. These two projects will place into close and safe communication the rest of the port with Jamaica bay. It must thus be seen that, from the standpoint of water facilities, with a tidal range of only 4.4 feet, Jamaica bay is worthy of consideration as a modern port.

The next question to be answered is whether or not Jamaica bay can provide a place for the necessary pier facilities. The pier is the connecting link between rail and water, and in the generic term pier facilities, must be included the wharfage face for vessels, the transit shed with its co-ordinated warehouses and industrial buildings.

The City of New York has a direct length of water-front of 578 miles, and there are available for purposes of commerce 406 piers with about 81 miles of wharfage on the sides of piers. This length

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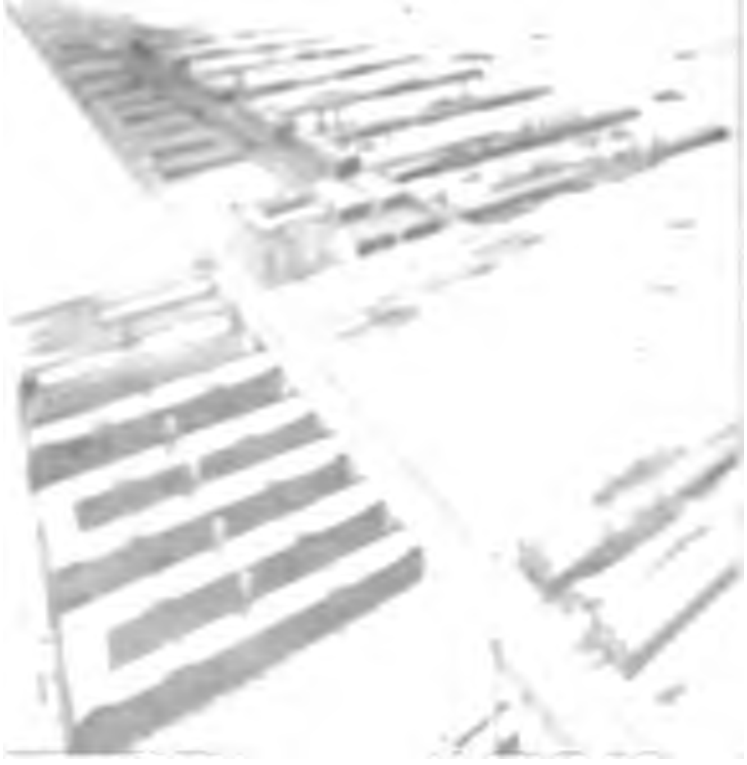

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bush avenue. Flatbush avenue is almost a straight line from Barren island to the East river where it is carried over the Manhattan bridge into Canal street, Manhattan. Canal street, in turn, leads directly to the entrance to the Vehicular tunnels now under construction, and which will provide a direct motor highway from New Jersey to the Jamaica Bay improvement. At the eastern end, the Cross Bay boulevard is under construction, and this will be united by means of the Woodhaven boulevard directly into Queens boulevard, which is widened to 200 feet. This will afford a motor highway from upper Manhattan and Queens into Jamaica, etc.

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Discussion

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[illegible]

[illegible] Marine [illegible] Committee [illegible]

[illegible] Commissioner of Docks, New York City.

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a few words. It is not his intention to criticise it, but merely to utter a word of caution. He has already called attention to the fact that there is a very large quantity of sand running from east to west along the coast and this eventually reaches the entrance to Jamaica bay. To keep the entrance channel open after it is once made, it is important to conserve as far as possible the water area of the bay, in order to take advantage of the scouring action of the ebb tide. The Jamaica Bay Improvement Commission paid particular attention to this phase of the project and the first plan produced was designed with this as a fundamental idea. If the interior of the bay were filled with sand or other solid material with the exception of the main channel, the water area would be lessened and the volume of the water flowing out of the bay at each tide would be proportionately smaller. The plan proposed by Mr. Ford, one of the commissioners, in a minority report which he published, was objected to by the speaker because it violated this principle. The author has widened the interior channel to 2,000 feet, so that the water area has not been depleted to the same extent as in the plan of Mr. Ford, but it is well to be cautious in the matter, and the speaker would suggest to the engineers now having the improvement in hand, to secure to the greatest degree possible the advantage of a large volume of water.

Although the speaker has said here he trusts the Dock Com- [illegible] the Chief Engineer will feel has not been said in [illegible] of the project itself or of the plans [illegible] is and always has been an earnest [illegible] reports made by him in connec- [illegible] is to see success attend

[illegible] The speaker would like [illegible] of Jamaica bay and [illegible] development of the shore [illegible] knowledge of the matter [illegible] partment of Docks. In [illegible] treasure of the Society, [illegible] rather not confuse [illegible] and half- [illegible] and

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[illegible] to [illegible] below the low-water mark [illegible] special waterproofing and protective [illegible] [illegible] layers of burlap and two layers of tarred [illegible] asphaltic cement, then wound with a [illegible] the [illegible] of which is laved a heavier exterior [illegible] not be [illegible] cement mortar or [illegible] These ties have been in place for several [illegible] of course, too short to tell how that they are [illegible] as far as they effective against the ice and [illegible] or any saw at the saw itself. At the Brooklyn [illegible] [illegible] protective coating hammered down [illegible] a 1,500-pound hammer, and it never shook off the [illegible] indication of the firmness and density. But it is [illegible] work. Whether this is the answer or not [illegible]

FRANCIS F. O'KEEFE.* —On the subject of the Jamaica Bay improvement, the speaker cannot add anything to the words of the author, who has covered the subject well and extensively from every new point.

The speaker may say that he represented the Chief Engineer and the Commissioner of Docks on the Marine Piling Committee, which pursued and is pursuing an exhaustive investigation into the general activities of marine borers in New York harbor and on means of prevention against their attacks; that investigation has not yet been drawn to a conclusion, and the speaker feels that until it has, it would not be proper for him to come here and give facts which should first be presented to the Marine Piling Committee.

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*Assistant Engineer, Department of Docks, New York City.

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You might think the speaker is a dreamer, but if James J. Hill was not the dreamer he was, you would have the Indians on the prairie yet. A gold mine is not any good until it is developed. The State ceded as its part of the agreement, 16,000 acres.

Now, no doubt, there have been men here who have been abroad many more times than the speaker has. In the Port of Hamburg, the conditions are like Jamaica bay. Every year, before the war, the City of Hamburg sold about 11,000,000 or 12,000,000 marks worth of this mainland,—not the marks as we know them to-day. It was not that 11,000,000 or 12,000,000 marks but the taxable area that was created on the land created every year.

The speaker does not think there has ever been anything printed or read on Jamaica bay that he has not read or heard. Jamaica bay is his hobby, but he has never heard a paper read that approved this cause so thoroughly as the author's paper does, and he does hope you will use every effort to give that paper the recognition due it, the publicity due it, and you surely will be doing something that your society will be proud of, and it will be a big plume in your hat.

PHILIP P. FARLEY,* M.M.E.N.Y.—The speaker was extremely interested in the author's paper because of its thoroughness and the clear manner in which the subject was presented and likewise on account of the speaker's connection with the Jamaica Bay Improvement Commission, appointed in 1906 by Mayor McClellan. His interest in this improvement has always been very great and for this reason he wants to take advantage of this opportunity to congratulate the Dock Commissioner, Deputy Commissioner Meyer and the Chief Engineer of the Dock Department on the progress that has been made through their efforts in recent months. From what has been stated in the paper, it is fair to assume that the improvement of the bay has reached a point where real practical results can be secured.

However, because of the speaker's former connection with the improvement, and because he is the only remaining living member of the Commission, he trusts he may be pardoned if he attempts to correct certain remarks of the Chief Engineer of the Dock Department as to the early history of the improvement. In speaking about this phase of the matter, and in outlining the work of the

* Past-President of the Society; Consulting Engineer, Office of President of Borough of Brooklyn.

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Commission, the speaker thinks, he failed to note what that Commission accomplished. He stated that the Commission, at the close of 1906, automatically went out of office and that the members were re-appointed. That is quite correct, except that he did not make clear that the Commission was practically continuously in office from May, 1906, until the early part of 1910 with the exception of one week.

Through an oversight, he also neglected to point out that the co-operative agreement between the City of New York and the United States Government, which was later embodied in House Document No. 1488, was the same in substance as the agreement entered into by the Jamaica Bay Improvement Commission with the United States Government, acting through Colonel Knight, United States District Engineer in New York City at the time. The lines of the improvement, so far as they affect the main channel, are practically as the Commission laid them out in 1909. At that time, it was agreed, as the Chief Engineer of the Dock Department has stated, that the original or preliminary improvement was to consist of an 18-foot channel 500 feet wide and that this would be widened to 1,000 feet and 30 feet deep. In accordance with that agreement, the Dock Department later dredged the channel as far north as the mouth of Mill Creek basin.

It has always been the speaker's opinion that the change in the harbor lines in front of Bergen beach which was made about 1917 was an unfortunate occurrence insofar as advancing the Jamaica Bay project was concerned because it was apparently the cause of many of the difficulties that were later encountered. If that channel had been immediately dredged as was intended as far as Fresh Creek basin and if Fresh Creek basin itself had been dredged up to Vandalia avenue, which is within 600 feet of the New York Connecting railroad, the speaker is convinced the improvement would have been at once self-sustaining because it was estimated at that time that this preliminary improvement would have cost the City of New York about three million dollars and that the effect of such an improvement would result in bringing into Jamaica bay over two million tons of commerce, equal to about one-half the tonnage of Newtown creek, which is one of the busiest water thoroughfares in the State of New York, but which has been in process of development for fifty years or more. If, therefore, the City had proceeded in 1910 to carry out this portion of the Jamaica Bay improvement project and could have advanced it along the lines re-

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ferred to without meeting with any difficulties it would have been in receipt of an income from this improvement for the past ten years.

What the speaker has just said is intended merely for historic accuracy and because he is desirous of having due credit given to the men who were his associates on the Commission and who were both members of this Society. For the same reason, it might be well to state in the records of this Society some of the things which the Jamaica Bay Improvement Commission accomplished. It is to be remembered, in the first place, that up to the time of the close of our first year on that work the Engineers of the United States Army had stated in reports that they were opposed to the United States Government doing anything in the way of improving Jamaica bay because of the difficulty in making an adequate entrance to the inlet and the speaker has always believed that it was because of the arguments advanced in the 1906 report of the Jamaica Bay Improvement Commission that a change in the attitude of the United States engineers was brought about and that eventually led to the agreement between the United States Government and the City of New York which has already been referred to and which is contained in House Document No. 1488.

The grant of land made by the State by which all the lands under water within the limits of Jamaica bay were conveyed to the City was also the work of the Commission and was in a particular manner due to the personal efforts of one of the members, Mr. William G. Ford, who died a short time ago.

In its 1906 report the Commission called attention to the need of a jetty at Rockaway point to protect the entrance to the bay. At that time it was estimated that the growth of Rockaway point westward had been at the average rate of 230 feet each year for the seventy years intervening between 1835 and 1905. Such a growth indicated that a very large quantity of sand was moving in a westerly direction along the Rockaway peninsula in each succeeding year so that if an attempt were made to create a channel into Jamaica bay from the entrance by dredging alone it would in all probability require a large yearly expenditure for maintenance and this would make the project very costly. The Government engineers at that time were inclined to the use of double or twin jetties and the proposal of the Jamaica Bay Improvement Commission to use a single jetty on the easterly side was to an extent at least novel, but this plan was subsequently adopted by the engineers for the Government

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and the author has stated that it is still the intention to follow this plan.

The author has also stated that it is proposed, as part of the general plan, to construct a canal from Gravesend bay to Jamaica bay to provide safe passage for light-draft boats. It was the speaker's opinion, expressed in the Commission's report, that this was not necessary. He does not believe that such a canal will ever be built, but the question should be settled one way or the other, and promptly. The failure to make a decision in the matter has caused considerable annoyance to the engineers of the Borough President's Office in Brooklyn for the reason that it is not possible to lay out a permanent street system or to provide necessary drainage facilities until this question is settled.

As the speaker has said, it is his personal opinion that a canal is unnecessary. He has always held this opinion and he has never heard a single reason advanced which would cause him to change his mind on the question but, on the contrary, he has had further proof of the soundness of his contention as a result of experience gained during the past year in connection with the work of improving the public beach at Coney island. In making the new beach, dredging was begun on August 21, 1922, and until about the middle of this month we have had a dredge in the Atlantic ocean 1,700 feet off-shore which has continuously operated twenty-four hours a day and it has never been obliged to stop or move by reason of the weather. The distance from Norton's point to the entrance of Jamaica bay is less than six miles, and it has always seemed to the speaker that it was unreasonable to contend that it was unsafe for a barge to make this short outside trip.

The author also mentioned a canal joining Jamaica bay with Flushing bay. It is admittedly a very dangerous and long passage to come by way of the East river or Hell Gate from the sound to Jamaica bay, and, therefore, a canal joining the two bays seems attractive. The speaker is satisfied, however, that it is altogether too late to undertake an enterprise of this kind. To construct a canal across the upland and in part through the high ridge running east and west through Brooklyn and Queens, would be very costly and would mean the interruption of every highway, railroad, sewer, and subsurface structure already built as well as a readjustment of all plans for streets and drainage already made.

With reference to the plan for improving the interior of the bay which was shown here to-night, the speaker would also like to say

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a few words. It is not his intention to criticise it, but merely to utter a word of caution. He has already called attention to the fact that there is a very large quantity of sand running from east to west along the coast and this eventually reaches the entrance to Jamaica bay. To keep the entrance channel open after it is once made, it is important to conserve, as far as possible, the water area of the bay, in order to take advantage of the scouring action of the ebb tide. The Jamaica Bay Improvement Commission paid particular attention to this phase of the project and the first plan produced was designed with this as a fundamental idea. If the interior of the bay were filled with sand or other solid material with the exception of the main channel, the water area would be lessened and the volume of the water flowing out of the bay at each tide would be proportionately smaller. The plan proposed by Mr. Ford, one of the commissioners, in a minority report which he published, was objected to by the speaker because it violated this principle. The author has widened the interior channel to 2,000 feet, so that the water area has not been depleted to the same extent as in the plan of Mr. Ford, but it is well to be cautious in the matter, and the speaker would suggest to the engineers now having the improvement in hand, to secure to the greatest degree possible the advantages of a large volume of water.

Anything the speaker has said here he trusts the Dock Commissioner and the Chief Engineer will feel has not been said in any spirit of criticism either of the project itself or of the plans as now proposed, as the speaker is and always has been an earnest advocate of the improvement as all reports made by him in connection with it will indicate. His only desire is to see success attend their efforts.

HENRY R. ASSERSON,* M.M.E.N.Y.—The speaker would like very much to say something about the islands of Jamaica bay and what has been talked about here upon the development of the shore line, but he is not fully prepared, due to his knowledge of the matter being contained in official reports to the Department of Docks. In the future it may be his pleasure, if it is the pleasure of the Society, to give you a few words, but the speaker would rather not confuse the subject now by giving you something disconnected and half-baked as it would appear from what he could say this evening, and he would rather wait until some future time.

* Assistant Engineer, Department of Docks, New York City.

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CHARLES U. POWELL,* M.M.E.N.Y.—In figuring this 10 cents a yard that the Government will pay, if the sand is pumped back of the bulkhead on land owned by the City, will that enter into the calculation as to what it costs to excavate the sand? If the City of New York pumped out sand at 10 cents a yard, and dumped it on their lands, and it was worth 5 cents a yard to the City to get it there, will that decrease the amount to be paid by the Government?

MR. KELLER (the Author).—No, the Government will pay to the City the contract price up to 10 cents a yard. They figured the cost would be 12 cents, but they have rebated against the City for that very purpose you spoke about.

JOHN W. F. BENNETT,† M.M.E.N.Y.—The speaker dislikes to open a large subject, but he would like to get the author's opinion on the question of marine borers in Jamaica bay,—whether any provision has been made in design to prevent the destruction of wharf structures by them, or whether any sewer outlets have been designed to so pollute the water that we probably would have no trouble from them.

MR. KELLER.—In the construction at the foot of Flatbush avenue, we used reinforced-concrete piles, a reinforced-concrete superstructure and paved with granite; except for fender piles, there is no wood in the construction.

What the preceding speaker has said about the type of construction to be placed in Jamaica bay is a real serious question, and we are considering it very seriously at present. The type of construction, as stated in the paper, for the piers, will be filled-in piers, which is simply a continuous line of retaining-wall built around the piers. Now there will be, around the islands and around the piers of Jamaica bay, perhaps, roughly speaking, eighty miles of bulkhead, so the type to be selected is one that should receive, and is receiving, very serious consideration. To be real frank, we are not convinced that reinforced concrete is the answer,—we are not convinced that creosoted piles is the answer. What will be done we cannot tell, because we have not made up our minds. We have a type of construction in Mill basin which consists of reinforced-

* President of the Society; Engineer in Charge, Topographical Bureau, Office of President of Borough of Queens.

† Chief Constructing Engineer, American Sugar Refining Company, New York City.

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concrete piles protected from two feet below the low-water mark to the top of the pile with a special waterproofing and protective cement consisting of three layers of burlap and two layers of tar-paper, each cemented with asphaltic cement, then bound with a very light reinforcing wire, on top of which is placed a heavier expanded metal, and into this is shot one inch of cement mortar by means of a cement gun. These piles have been in place for perhaps a year, which is, of course, too short to tell you that they are the real thing, but as far as being effective against the ice and frost, the author can say that he saw, himself, at the Brooklyn bridge, a similar pile with this protective coating hammered down with 100 blows of a 7,500-pound hammer, and it never shook off the coating, giving an indication of the firmness and density. But it is very slow and expensive work. Whether this is the answer or not the author cannot tell.

FRANCIS T. O'KEEFE.*—On the subject of the Jamaica Bay improvement, the speaker cannot add anything to the words of the author, who has covered the subject well and extensively from every view-point.

The speaker may say that he represented the Chief Engineer and the Commissioner of Docks on the Marine Piling Committee, which pursued and is pursuing an exhaustive investigation into the general activities of marine borers in New York harbor and on means of prevention against their attacks; that investigation has not yet been drawn to a conclusion, and the speaker feels that until it has, it would not be proper for him to come here and give facts which should first be presented to the Marine Piling Committee.

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* Assistant Engineer, Department of Docks, New York City.

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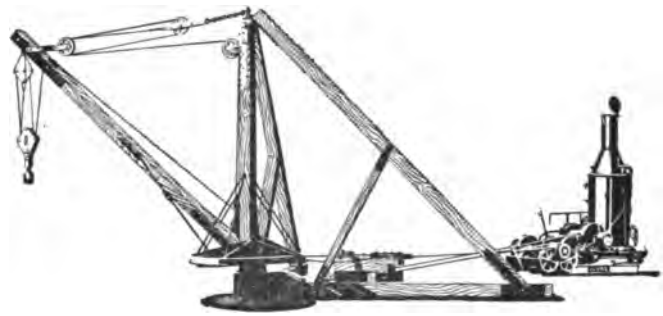

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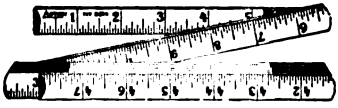

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